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DEPARTMENT OF THE ARMY TECHNICAL MANUAL

OVERHAUL INSTRUCTIONS
AIRCRAFT ENGINE
TYPE 0-470-11
(L-19 AIRCRAFT)
(CONTINENTAL)

HEADQUARTERS, DEPARTMENT OF THE ARMY

DECEMBER 1960

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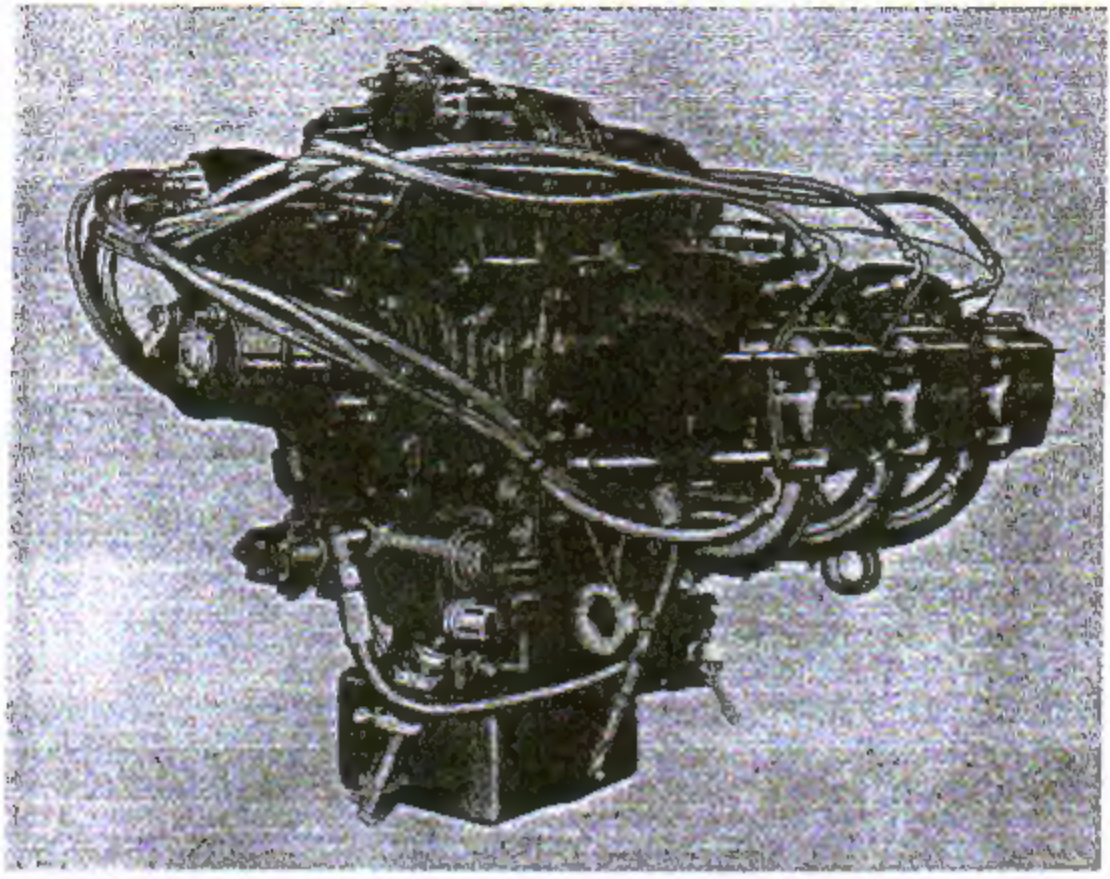

Figure 1–1. Three Quarter Right Rear View of Engine

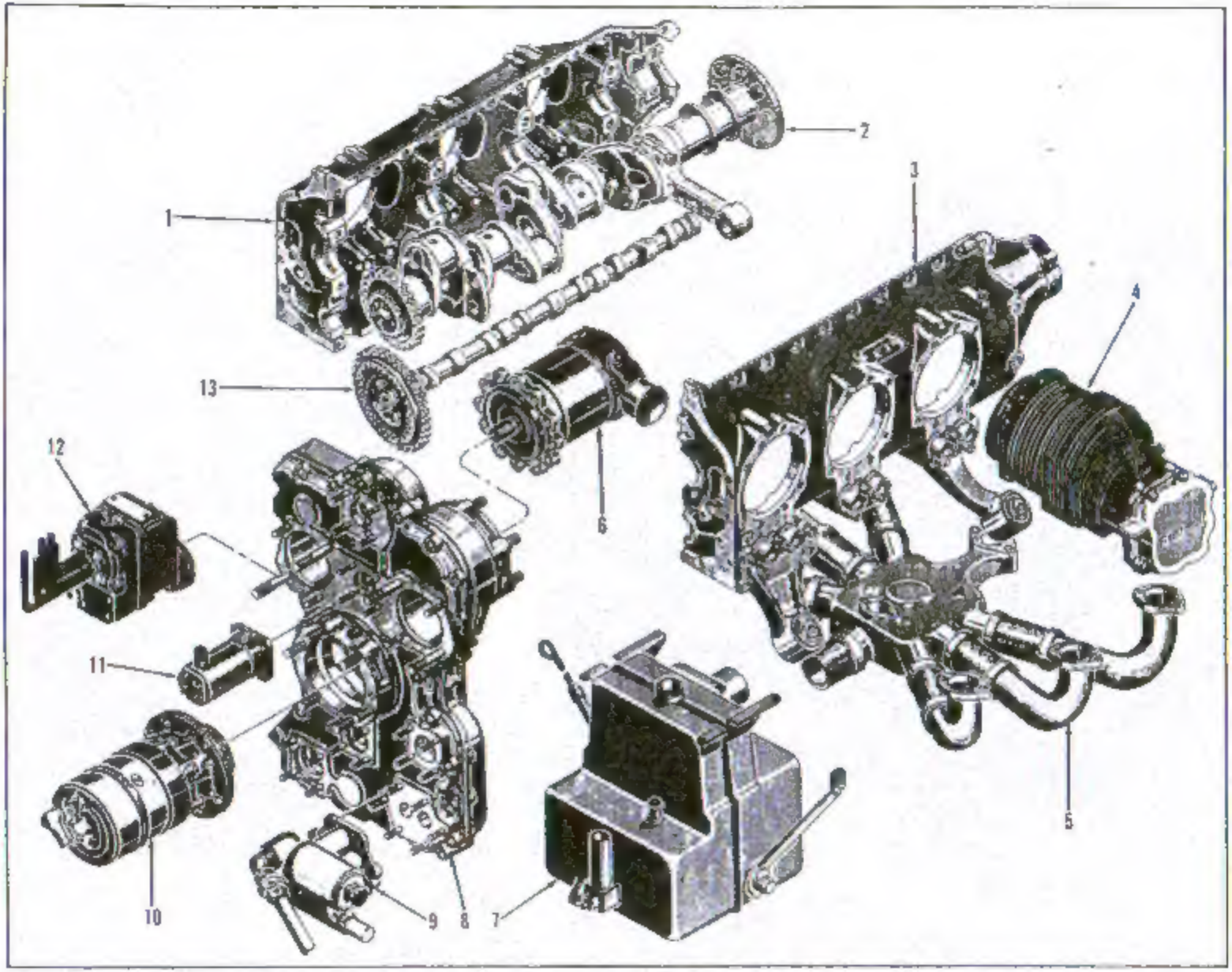

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Figure 1–2. Engine Component Assemblies

SECTION 1

INTRODUCTION

1-1. SCOPE.

1-2. This Technical Manual comprises the overhaul instructions for the type O-470-11 aircraft engine (figure 1-1) manufactured by Continental Motors Corporation, Muskegon, Michigan.

1-3. ENGINE SECTIONS.

1-4. In figure 1-2, all major sections and accessories of the engine, as supplied by the engine manufacturer, are identified by appearance, relative location, and correct nomenclature.

1-5. TERMS.

1-6. Terms used in this Technical Manual are defined as follows:

a. After Top Center (A.T.C.): Positions of piston and crankpin after passing outward end of stroke.

b. Backward Rotation: In direction opposite normal operation.

c. Before Top Center (B.T.C.): Piston and crankpin positions on outward stroke, before reaching Top Dead Center.

d. Bottom (or lower side): Normally refers to positions on downward side of engine or part in installed position. Also, toward open (skirt) end of cylinder.

e. Forward Rotation: In direction of normal operation.

f. Front: Propeller end of engine.

g. Outward (or outer): Positions and directions away from the center of the engine and its assemblies, when in operating position.

h. Rear: Accessory drive end of engine.

i. Right Side: Determined when the engine is viewed from the rear.

j. R.M.S.: Root mean square (mathematical average).

k. Top: Normally, positions on upward side of engine and its assemblies when in normal operating position. Also indicates outer, or head end of cylinders.

l. Top Dead Center: Piston and crankpin position at outward end of stroke.

m. Clockwise: Same direction of rotation as hands of clock when rotating part is viewed from rear end of engine. Counterclockwise direction is opposite.

1-7. CYLINDER ARRANGEMENT.

1-8. Cylinders are attached to left and right sides of crankcase. The odd numbered cylinders are on the right side, number one at the rear, number three in the center, and number five at the front. Even numbers are on the left, number two at the rear, number four in the center, and number six at the front. These positions are shown in figure 1-3.

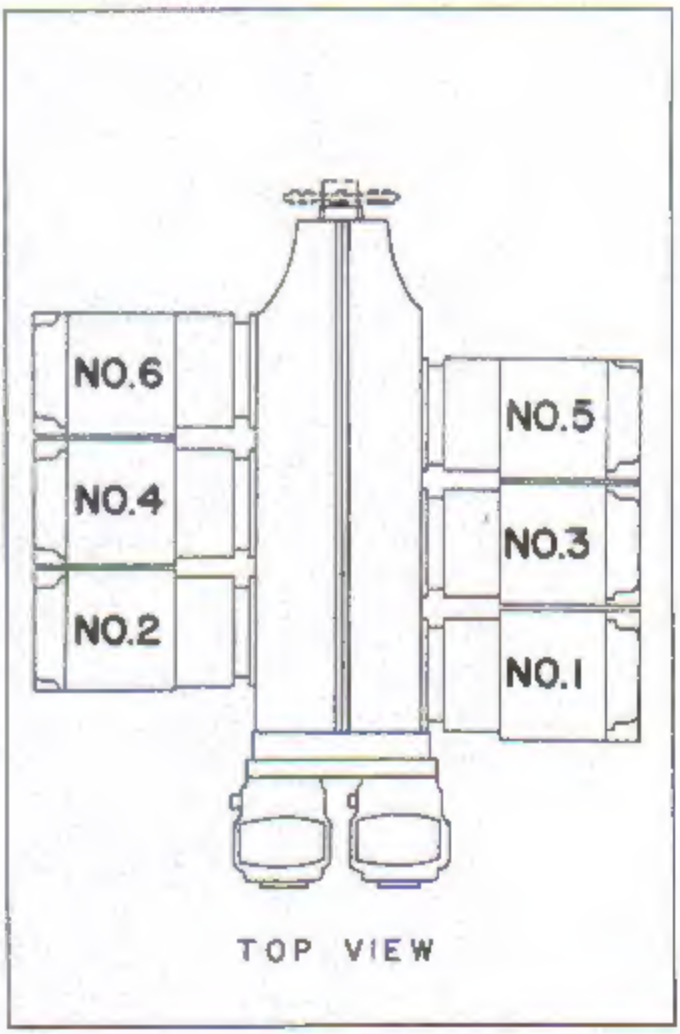


Figure 1-3. Cylinder Arrangement Diagram

1–9. MEASUREMENT.

1–10. In this Technical Manual, frequent reference is made to the Table Of Limits, Section X. Use this table for all operations involving measurement or use of gages other than special plug gages listed in Section III. Special gages must be checked periodically with accurate micrometer calipers to detect wear and need for replacement. The standard temperature for grinding and checking these gages is 20°C (68°F).

1–11. REFERENCES TO ILLUSTRATIONS. Index numbers in illustrations are connected by "leader" lines to the parts described opposite those same numbers in the legends appearing between the illustrations and their captions. The index numbers called out in the text to indicate the same parts are placed in parenthesis immediately following the part names, for instance "(9)" indicates index number 9 in figure X named at the beginning of the paragraph as, for instance "(See figure X.)". All index numbers appearing in the same paragraph then refer to figure X, unless an expression such as "(13, figure Y)" appears, in which event that reference only is to figure Y, and all preceding and following index numbers in that paragraph without special identification refer to figure X.

SECTION II

GENERAL DESCRIPTION

2-1. STARTER.

2-2. The direct cranking starter is mounted on an adapter attached to the rear center of the accessory case and directly in line with the crankshaft. The starter's three-jaw driving clutch is driven through a Bendix drive and moves forward as the starter motor begins to turn, meshing with a jaw which is supported on a stud at the rear end of the crankshaft. The engine jaw drives the crankshaft gear through mating splines, and the gear turns the crankshaft.

2-3. GENERATOR.

2-4. The 24-volt generator has a maximum output of 50 amperes to charge the aircraft battery. It is mounted on an adapter on the forward side of the accessory case at the upper right corner. Since the generator's splined drive shaft is connected to the armature through a shock absorbing coupling, no flexibility is built into the engine's generator drive. The generator drive gear bears in the adapter and meshes with teeth on the large wheel of the right magneto cluster gear.

2-5. IGNITION SYSTEM.

2-6. Dual spark ignition is provided by two Scintilla magnetos which incorporate impulse couplings to provide a hot spark at full retard for starting. Two lugs on the front side of each impulse coupling cup are driven by cluster gears in the accessory case. Ignition harnesses consist of braided copper flexible shield conduits, with flanged tubular metal ends and high tension insulated cables. These are attached to cable outlet plates and shielded spark plug elbows. Lower conduits are supported by brackets attached to the accessory case. Ignition cables lead from the distributor housing of the right magneto to the six upper spark plugs and from the left magneto to the six lower spark plugs. The engines have 18 mm shielded ceramic spark plugs.

2-7. CRANKCASE ASSEMBLY.

2-8. Left and right halves of the crankcase are aluminum alloy castings. The two halves (also called sides) are joined at a parting surface which coincides with the longitudinal, vertical center plane of the engine. The crankshaft and camshaft are also centered on this plane by bearings in the crankcase, one half of each bearing being machined in each casting. The camshaft bearings are machined directly in the case metal. Seats for automotive type, precision bearing inserts, which form the split crankshaft main bearings, are machined above the camshaft bearings. The front main bearing is flanged and serves as a thrust bearing. The bearing bosses are integral parts of webs molded in the lateral direction in each casting and meeting at the parting surface. Through bolts, threaded at each end, pass through holes drilled through the bearing bosses and webs immediately above and below the main bearings and extend through cylinder mount pads on left and right sides of the crankcase, serving to attach cylinder mount flanges and to tie the case halves together. Two shorter, hex head bolts pass through holes above and below the front main bearing. Two long, hex head bolts pass through attaching flanges of rear engine mount brackets and through the crankcase lying between. A shorter hex head bolt passes through a case hole between the front and rear through bolts of the mount brackets. Upper and lower parting flanges of the case castings are attached by short screws and nuts, two of which also serve to attach the engine lifting eye. An oil inlet from the externally mounted pressure oil pump discharge hose is provided by a pipe tapped hole into the right oil gallery between No. 1 and 3 cylinders. A 45-degree elbow connects the hose. The front end of the right oil gallery is not plugged, except during block test. An adapter is screwed into the plug hole and enters the gallery tube far enough to cover the cross oil passage to the front camshaft bearing. To this adapter is connected a hose leading to the oil cooler. Before the engine is installed for service, a plug closes the front end of the left oil gallery; however, this is removed during engine installation and an aircraft fitting is installed, in its place, to receive the oil cooler outlet hose. Pushrod housing flanges are designed to work with pushrod housings which can be removed with cylinders in place. Structurally, the crankcase includes a cast aluminum alloy distributor for the cylinder head priming system installed on the engine. The distributor is installed under the head of an extra length bolt through the upper case parting flanges immediately ahead of the engine lifting eye. Special flanged nuts and nut locks are installed on through bolts at the main bearing and cylinder pad. Seven studs installed in the rear parting flange of the crankcase furnish five points of accessory case attachment

at the sides and two at the bottom, while four Helicoils installed along the top of the flange and one at the lower right corner provide the remaining five points for attachment with screws. Upper extensions of the crankcase rear parting flange are not provided. Neither a starter pinion pivot nor magneto gear supports are installed. Engine mount brackets attached to the crankcase are designed for horizontal mounting bolts. Rubber dampeners are separate, cone shaped pieces, of which one is installed on the forward side and one on the rear side of each bracket.

2-9. OIL SUMP AND DRAIN TUBE.

2-10. The pressed steel sump is cube shaped at the bottom and has an upper neck, attached to the six crankcase bottom surface studs by lugs welded to the neck and retained by plain nuts. An opening near the left rear corner of the upper surface of the cubical body is connected to a drain hole in the bottom of the accessory case by a hose nipple. This nipple is connected by a hose to a hose adapter which is screwed into the bottom of the accessory case. The screw inserts for the drain plug and the support brackets are not provided with lock wire anchor lugs. The side support brackets are identical and consist of steel tubes, flattened at each end and drilled to receive the mount bracket studs (at outer sides of castings) and the sump attaching bolts. The drain boss is welded into the lower rear edge of the sump, instead of the center. Near the drain boss another tapped insert receives a suction oil screen assembly consisting of a perforated tube, a pipe threaded elbow, and a hose connector tube. The perforated "screen" tube projects horizontally into the sump near its bottom surface, and the elbow pipe thread is tightened in the sump boss to align the perpendicular connector tube with the oil pump inlet adapter. A synthetic rubber hose connects the screen assembly to the pump adapter. The screen elbow has a 1/8-inch pipe tapped hole at the rear for installation of an oil dilution line. An oil gage rod is held by friction in a boss welded into the sump.

2-11. INDUCTION SYSTEM.

2-12. Included in this system are the carburetor, fuel pump, intake and oil drain manifold, intake tubes, and attaching parts.

2-13. The intake and oil drain manifold is attached with two screws through each of the bottom crankcase pads. A gasket at each joint seals the front and rear oil inlets. The manifold is a cored casting with a central air box opening at the bottom into a hole centered in the machined pad to which the carburetor is attached by four manifold studs. Outlets from the air box spread horizontally toward the cylinders in tubular shape. The cored manifold oil drain passage starts at an inlet hole centered in the front mount boss and extends rearward, separating and passing to left and right of the air box and rejoining into a single outlet at the rear. A second inlet hole, centered in the rear manifold mount pad, opens into the rear of the cored oil passage behind the air box. In the engine assemblies equipped with the manifold described above, the front oil drain tube is replaced by a cover plate which closes the bottom of the manifold front mount boss, forcing the oil to drain through the manifold passage. The No. 534204 manifold is not bored through at the front boss and requires no cover plate.

2-14. Six aluminum intake tubes of the same length are curved from the horizontal manifold outlets to the vertical intake ports of cylinder heads. Hoses and clamps attach the tubes to the tubular manifold outlets. Upper tube ends are attached and sealed to cylinder heads by special rubber seal rings of oval cross section placed in grooves near the tube ends and by loose aluminum flanges, which hold the seal rings into the cylinder ports and are retained by two screws each.

2-15. The Stromberg carburetor is a single-barrel, pressure-type unit, mounted on the bottom flange of the manifold. The carburetor is equipped with a throttle lever and a combined manual mixture control and idle cut-off lever. A "Rose Head" discharge assembly and four tapered tubular nozzles are built into the carburetor.

2-16. All engines have a Romec vane-type fuel pump. One pump is installed on each engine. It is mounted on the accessory mount pad at the lower left corner of the accessory case rear surface. The fuel pump incorporates an adjustable pressure relief valve and a by-pass valve. The hose connection from fuel pump to carburetor is supplied by the aircraft manufacturer.

2-17. Fuel is supplied to the carburetor by the fuel pump at a pressure of 9-13 pounds per square inch. The Stromberg pressure carburetor meters the fuel into the intake air stream passing through its barrel by injection from a nozzle located above the throttle valve. The fuel-air mixture delivered to the intake manifold by the carburetor divides among the six intake tubes attached between manifold and cylinder intake ports. The mixture is forced into the combustion chambers by atmospheric pressure and the ram effect of the air scoop to fill the volume displaced by each piston on its intake stroke. The engine is equipped with a cylinder head priming system, which consists of a cast aluminum distributor attached to the crankcase upper parting flanges, six union nipples screwed into the distributor outlet holes, six primer nipples screwed into cylinder intake valve chamber holes, and six connecting tube assemblies. The distributor or manifold primer jet is fed by an aircraft line from the pilot's hand priming pump.

2-18. CYLINDERS.

2-19. The cast aluminum alloy cylinder head is

screwed and shrunk onto the forged steel barrel to make the permanent cylinder head and barrel assembly. The bore is parallel in its lower half and choked (tapered) in the upper half. Intake and exhaust valves seat in steel inserts shrunk in valve ports at the cylinder head surface. Valve stems pass through bronze guides into the rocker box. An inner and outer valve spring surround each valve stem and seat in a steel retainer. Steel outer valve spring retainers are keyed to valve stem grooves by split locks. Rocker arms bear on a tubular, floating shaft carried in three support bosses cast integrally in the head. Rockers contact the valve stem tips with zero lash. Pushrods extend below the cylinder from rocker sockets to valve lifter sockets through tubular housings sealed to cylinder heads and to pushrod housing flanges by rubber rings. The flange for each pair of housings is attached with three studs to the side of the crankcase below the cylinder and covers the outer ends of two valve lifters. A soft gasket is installed between the flange and the case pad. This arrangement provides an oil-tight passage for oil draining from the rocker box. Intake and exhaust ports are located on the lower side of the cylinder head. Two studs in the exhaust flange provide for exhaust pipe attachment. Tapped holes in the intake flange receive screws which attach the intake tube retaining flange. Engine cylinders are equipped with 18mm spark plug Helicoils. The cast rocker cover is sealed to the rocker box flange with a soft gasket and retained by seven fillister head screws, internal tooth lock washers, and plain washers. The center rocker shaft support boss has a chamfered oil hole at the top to admit more oil to the bearing surface. The cylinder requires a rocker box cover which is wider at the bottom to clear the support bosses. The cylinder head has holes for pushrod housing oil seal rings bored through the rocker box wall full depth. The straight bore permits removal of the pushrod housings with cylinders in place. The housings have additional bends at the cylinder ends to locate hairpin type housing retainers which bear on the rocker box underside and hold the housing inward.

2–20. PISTONS AND RINGS.

2–21. The engine has pistons which are machined aluminum alloy forgings. The pistons have concave heads and solid skirts. Three piston rings are carried in grooves above the piston pin. The piston skirt is cam ground to an eliptical contour in order to fit the cylinder wall closely when expanded at operating temperature. The top piston ring is a chrome faced compression ring, bevelled on the top of the inside surface. The second groove compression ring is also chrome faced and similarly bevelled. Both compression rings are tapered from bottom to top on the face so that the bottom sides will wear in first and will provide a scraping action. The taper allows rapid ring seating. The oil control ring in the third groove is a wider, center-slotted ring with the face wearing surfaces above and below the slots tapered toward the center slots. Four oil drain holes from the back of the third ring groove lead to the interior of the piston. The piston skirt, below the third ring groove, tapers in diameter, becoming larger at the bottom. This design compensates for greater expansion at the piston head. The full floating piston pin bears in two heavy bosses molded in the piston and bored to a very smooth and accurate surface. The tubular steel pin is retained endwise by an aluminum plug. The piston pin has a solid aluminum plug extending through and beyond the ends, where it is hot forged to lock in place.

2–22. CRANKSHAFT.

2–23. The engine has a crankshaft with an S.A.E. No. 4 propeller mounting flange. The propeller flange has eight tapped steel bushings for propeller attaching bolts. The crankshaft oil seal fits tightly in a counterbore at the front end of the crankcase. The seal is a non-metallic (rubber compound) ring split to permit installation and compressed on the shaft race by a helical spring, whose ends are hooked to form a circle inside a recess in the rear side of the ring. To the rear of the seal race, the crankshaft front main journal has front and rear thrust flanges to limit shaft end movement. The rear flange transfers propeller thrust to the flanged front main thrust bearing, composed of two semi-circular steel-backed silver inserts plated with a dull gray alloy of lead-indium. The other four crankshaft main journals are carried in bearings, each of which is formed by two semi-circular inserts of steel-backed, lead-plated bronze without flanges. All bearing inserts have locating tangs which engage crankcase notches. The crankshaft is center bored from the front end to the front crankcheek, with the front end bore of the shaft closed by a Hubbard plug. A permanently installed "U" tube in the crankshaft front end bore forms an oil passage from the second main bearing to the front main thrust bearing. Straight steel tubes pressed into crankcheek holes provide oil passages from the main bearings to crankpin bearing surfaces. Attached by two loose fitting fulcrum pins to a blade extension at the side of the No. 1-2 crankcheek, each of two counterweights is free to oscillate within a limited arc in pendulum fashion. These weights act as dampers to prevent any torsional vibration in the crankshaft from acting on the gear train. Hardened steel bushings are pressed into the crankshaft pin holes and similar bushings in the counterweight pin holes to resist wear. The damper pins are also hardened steel plates and Truarc snap rings. The crankshaft rear end projects through the rear crankcase web and bearing. Its end surface has an off center dowel to drive the accessory drive gear and six tapped holes for gear retaining screws. The crankshaft rear end is drilled and tapped in the center for a large, tight fitting stud which pilots and retains the starter jaw.

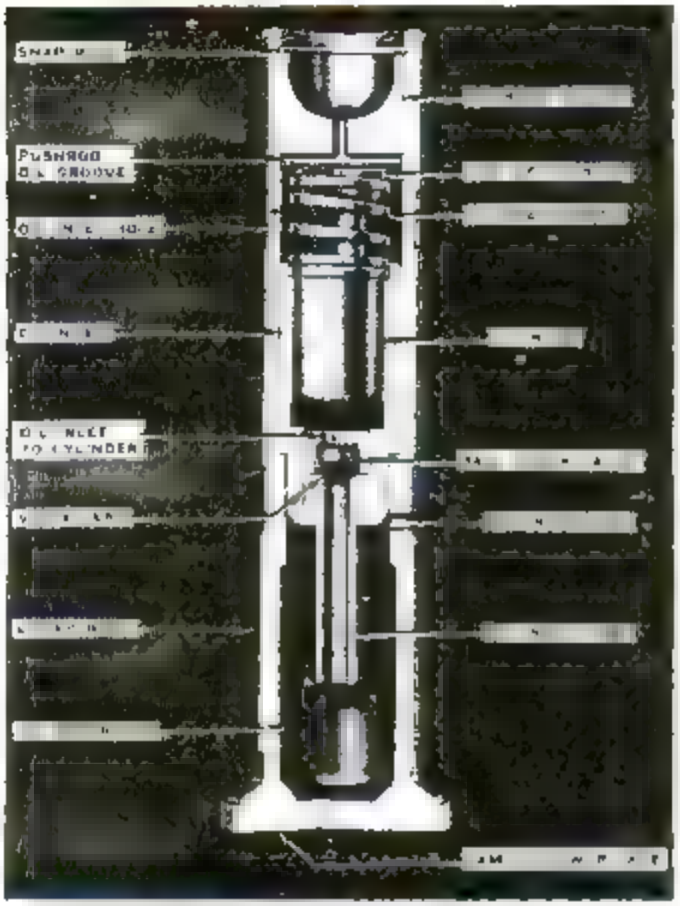


Figure 2–1. Cutaway View of Hydraulic Valve Lifter

2–24. CONNECTING RODS

2–25. Standard automotive type rods which split big ends and Bronze bushed piston pin ends are made of steel forgings. The big end bearing caps are retained by two special bolts and slotted nuts. Crankpin bearings are precision, steel backed, Tri-Metal bronze, semi-circular inserts plated with lead. Tangs of the inserts engage in the rod and cap. The beam has an "H" cross section. The piston pin bushing is split. Rods and caps have position numbers stamped on the upper bolt boss.

2–26. CAMSHAFT.

2–27. The shaft has four ground journals. Between each two are three cam lobes. In each group, the center lobe operates two opposite intake valve lifters while the other two operate one exhaust valve lifter each. The toes of all lobes are tapered from end to end in order to rotate the valve lifters. Flanges at front and rear ends of the rear journal restrict camshaft end movement. A large flange at the rear end of the shaft centers and pilots the camshaft gear and has four tapped holes for gear retaining screws. The front camshaft journal has a deep groove in the center of its length to conduct oil from the left crankcase cross over passage to the cross drilled hole in the right case casting

2–28. HYDRAULIC VALVE LIFTERS.

2–29. Each lifter assembly is composed of a hollow lifter body, a hydraulic unit, and a pushrod socket (See figure 2–1.) Contact with the cam lobe is made through a large, flat round follower formed on the inner end of the body. The hydraulic unit is housed within the hollow body shank. It consists of a cylinder assembly and a plunger and expanding spring assembly The cylinder has an oil inlet tube extending from its inner end. Inside the cylinder and covering the oil inlet is a ball check valve in a retainer, The plunger fits closely in the open outer end of the cylinder. Its expanding spring bears in a counterbore in the end of the cylinder. The cylinder seats on a shoulder in the lifter body bore. The pushrod socket rests against the outer end of the plunger and is retained in the end of the body bore by a wire snap ring. It is cross grooved on its flat, inner surface and drilled through to the socket spherical cavity for oil passage to the pushrod. A groove around the lifter body shank and a flat on the cylindrical surface registrer with the crankcase oil passage from the main gallery when the cam follower is on the toe of the cam lobe. A hole from the inner end of the flat to the body interior reservoir feeds the hydraulic unit, while a second hole through the body wall at the outer end of the flat feeds oil to the pushrod socket. The valve train is so proportioned that dry valve lifters may be fully compressed to give 0.035 to 0.050 inch clearance between the rocker and the valve stem tip. Lifters are designed to operate when this "dry" clearance is 0 030 to 0.110 inch When filled with oil, the lifter allows no valve clearance. The plunger expanding spring takes up any increase in rocker shaft to camshaft distance, due to engine expansion, each time the valve closes. The increased volume between the inner end of the plunger and the inner end of the cylinder of the hydraulic unit is filled by intake of engine oil from the lifter body reservoir so that the train is readjusted to the required length with the rocker still in contact with the valve stem tip. Cooling and resulting contraction of the engine are compensated by reduction of the effective length of the lifter through "leak-down" of oil past the unit plunger. This rate is closely controlled by selection of parts of the hydraulic unit, which are not interchangeable.

Note

Original valve lifters, installed in combination with cast iron camshafts, have steel cam follower faces. Those installed with forged steel shafts must have cast iron followers to maintain the dissimilarity of contacting metals. Forged steel cam followers are 1/8-inch thick at the center. Those of cast iron are noticeably thicker and have no shoulder on the back side.

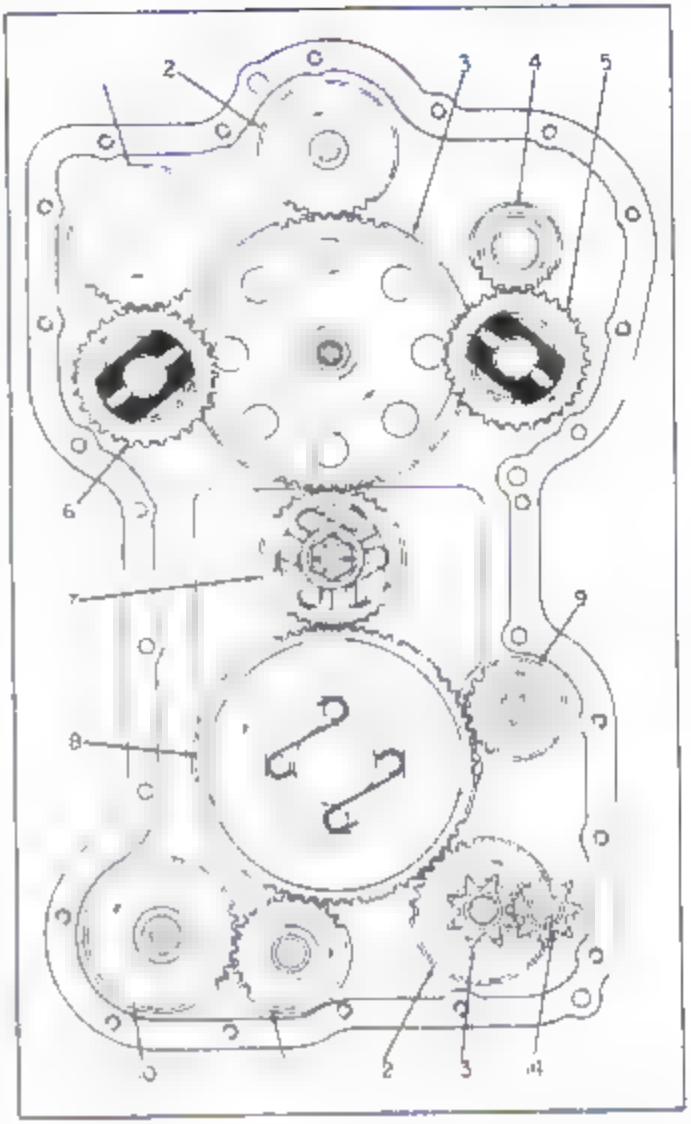
2–30. GEAR TRAIN.

2–31. GEAR DESIGN. All gears in the train are spur gears made from alloy steel forgings and finish machined all over. All gear teeth, shafts and other wearing surfaces are hardened and ground to final shape and size.

2–32. OPTIONAL GEARS. (See figure 2–2.) The upper hydraulic pump drive gear (1) and the propeller governor drive gear (2) are optional parts which are not supplied with the basic engine. They may be installed during any overhaul if required by the aircraft for which the engine will be assembled. When these gears are not installed, their bushings are fitted with steel sleeve plugs to prevent oil leakage.

2–33. GEAR CONSTRUCTION, MOUNTING AND TIMING. Gears identified by index numbers 1, 2, 3, 5, 6, and 9 in figure 2–2 have integral shafts which bear in bronze bushings pressed into the accessory case front half. Of these, gears numbered 1, 2, and 3 also have integral rear side shafts borne in bushings which are pressed into the accessory case rear half. The generator drive gear (4) bears in a bushing pressed into the generator adapter. The right and left magneto cluster gears (5 and 6) bear in rear bushings pressed into the two magneto adapters. The pinion gear (7) is piloted on the rear end of the crankshaft by a recess ground in its front side. It is located by a crankshaft dowel and retained by six hex head bolts. Centered in the crankshaft rear end is a tapped hole, into which a large stud is screwed tight to form a support for the starter jaw. The stud has a smooth support surface and a rear end thread for the jaw retaining slotted nut. External splines at the front of the starter jaw mesh with internal splines machined in the center bore of the pinion gear. At the rear side of the starter jaw, three teeth are formed by machining ramps and relief slots at equal angles around the circle. These teeth mesh with an AN standard three-jaw drive dog on the starter, which is mounted in line with the crankshaft. The camshaft gear (8) is piloted on a large flange at the rear end of the camshaft by a recess ground in its front side and is retained by four hex head bolts, one of which is unequally spaced to assure correct assembly in relation to the cam lobes. As shown in figure 2–2, a punched marked tooth of the camshaft gear is meshed between two marked pinion gear teeth which have a definite angular relation to No. 1 crankpin. Gears numbered 10, 11, 12, 13 and 14 in figure 2–2 bear in bushings pressed into the accessory case rear half. Of these, the oil pumping gears (13 and 14) also have rear shafts which bear in bushings pressed into the oil pump housing.

2–34 DRIVES. (See figure 2–2.) The upper hydraulic pump drive gear (1), when installed, and the generator drive gear (4) have internally splined driving shafts which project forward. The propeller governor drive gear (2), when installed, the lower hydraulic pump drive gear (9), the fuel pump drive gear (10), and the oil pump drive gear (12) have internally splined driving shafts projecting rearward. External splines on the integral front shaft end of the oil pump driver gear (13) mesh with the drive gear splines. Rear shaft ends of the magneto cluster gears are slotted and sleeved, to accommodate the magneto drive couplings. The rear shaft end of the upper tachometer drive gear



1 UPPER HYDRAULIC PUMP DRIVE GEAR (OPTIONAL)
2 PROPELLER GOVERNOR DRIVE GEAR (OPTIONAL)
3 UPPER TACHOMETER DRIVE GEAR
4 GENERATOR DRIVE GEAR
5 RIGHT MAGNETO CLUSTER GEAR
6 LEFT MAGNETO CLUSTER GEAR
7 PINION GEAR
8 CAMSHAFT GEAR
9 LOWER HYDRAULIC PUMP DRIVE GEAR
10 FUEL PUMP DRIVE GEAR
11 FUEL PUMP IDLER GEAR
12 OIL PUMP DRIVE GEAR
13 OIL PUMP DRIVER GEAR
14 OIL PUMP DRIVEN GEAR

Figure 2–2. Rear View of Gear Train

(3) has a broached square hole to receive the squared end of an electric tachometer generator drive shaft.

2–35. OTHER GEAR DATA. In Table I are listed the gear ratio and rotation data relative to standard and optional gears in the train illustrated in figure 2–2. Table II provides information relative to accessory drives, including shaft details.

2–36. ACCESSORY CASE.

2–37. COMPOSITION AND ATTACHMENT. (See figure 2–3.) The accessory case front and rear machining assembly (45) is composed of front and rear half machining and studding assemblies and their attaching parts. This assembly is attached over the accessory case to crankcase gasket (58) to five long studs, driven into the crankcase rear flange, by nut locks (46), plain nuts (47), and plain washers (48). In addition, the front half casting (phantom view at lower right) is attached to two crankcase studs by cotter pins (49), castle shear nuts (50), and plain washers (51) and to one lower and four upper crankcase Helicoil inserts by lock wire (55), hex head bolts (52 and 56), tab washer (53), and plain washers (54 and 57). Early models had cases with a shallow bolt boss (at the location of index 52), and used a shorter bolt than that presently installed. This shorter bolt was safetied with a lock wire, but a tab washer (53) is equally satisfactory. Attaching parts and attached parts illustrated in "exploded" positions and installed parts illustrated in the lower left phantom view are not included in the front and rear machining assembly. These, with the exception of case attaching parts, plus the oil pump assembly are required to make up the manufacturer's complete accessory case assembly, which is not supplied in the fully assembled condition.

2–38. ATTACHED PARTS. (See figure 2–3.) Covers numbered 8, 13, 23, and 28 are installed on accessory mount pads for shipment when accessories are not installed. The oil filler spout assembly, formed by pressing the oil filler neck (6) into the oil filler spout (7), is attached, over a gasket (5), to the studded pad

1 OIL FILLER CAP ASSEMBLY
2 NUT LOCK
3 PLAIN NUT
4 PLAIN WASHER
5 GASKET
6 OIL FILLER NECK
7 OIL FILLER SPOUT
8 PROPELLER GOVERNOR DRIVE COVER
9 NUT LOCK
10 PLAIN NUT
11 PLAIN WASHER
12 GASKET
13 UPPER HYDRAULIC PUMP DRIVE COVER
14 NUT LOCK
15 PLAIN NUT
16 PLAIN WASHER
17 GASKET
18 STARTER ADAPTER
19 NUT LOCK
20 PLAIN NUT
21 PLAIN WASHER
22 GASKET
23 LOWER TACHOMETER DRIVER COVER
24 NUT LOCK
25 PLAIN NUT
26 PLAIN WASHER
27 GASKET
28 LOWER HYDRAULIC PUMP DRIVE COVER
29 NUT LOCK
30 PLAIN NUT
31 PLAIN WASHER
32 GASKET
33 HOSE NIPPLE
34 COPPER-ASBESTOS GASKET
35 NUT LOCK
36 PLAIN NUT
37 PLAIN WASHER
38 NUT LOCK
39 PLAIN NUT
40 PLAIN WASHER
41 NUT LOCK
42 PLAIN NUT
43 PLAIN WASHER
44 NUT LOCK
45 ACCESSORY CASE FRONT AND REAR MACHINING ASSEMBLY
46 NUT LOCK
47 PLAIN NUT
48 PLAIN WASHER
49 COTTER PIN
50 CASTLE SHEAR NUT
51 PLAIN WASHER
52 HEX HEAD BOLT
53 TAB WASHER (SERIAL NO. 100846 AND HIGHER)
54 PLAIN WASHER
55 LOCK WIRE, BRASS
56 HEX HEAD BOLT
57 PLAIN WASHER
58 ACCESSORY CASE TO CRANKCASE GASKET
59 OIL PLUG
60 UPPER TACHOMETER DRIVE GEAR
61 OIL PLUG
62 LOWER HYDRAULIC PUMP DRIVE GEAR
63 OIL PUMP DRIVE GEAR
64 FUEL PUMP IDLER GEAR
65 OIL PLUG
66 FUEL PUMP DRIVE GEAR
67 UPPER HYDRAULIC PUMP DRIVE PLUG
68 PROPELLER GOVERNOR DRIVE PLUG
69 TRUARC EXTERNAL SNAP RING
70 LOWER TACHOMETER DRIVE PLUG
71 STARTER JAW OIL SEAL
72 GENERATOR DRIVE OIL SEAL
73 UPPER HYDRAULIC PUMP DRIVE OIL SEAL
74 LOWER HYDRAULIC PUMP DRIVE OIL SEAL
75 UPPER TACHOMETER DRIVE OIL SEAL
76 FUEL PUMP DRIVE OIL SEAL
77 TRUARC EXTERNAL SNAP RING
78 ALUMINUM THRUST WASHER
79 OIL PLUG
80 GENERATOR DRIVE GEAR
81 MAGNETO DRIVE GEAR SLEEVE
82 MAGNETO DRIVE GEAR
83 MAGNETO DRIVE SHAFT GEAR

Figure 2–3. View of Accessory Case (Sheet 1 of 2)

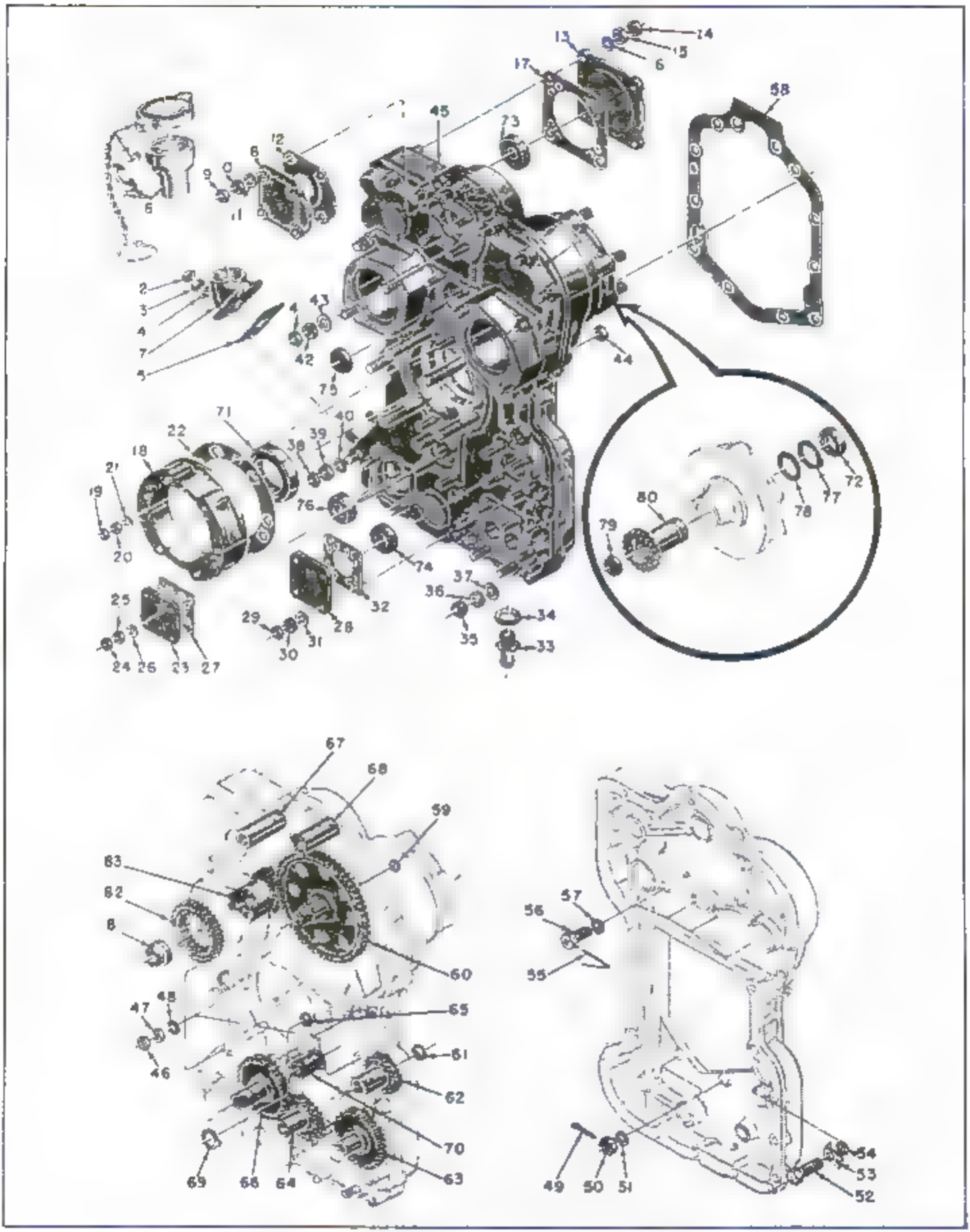


Figure 2–3. View of Accessory Case (Sheet 2 of 2)

TABLE I. GEAR DATA

DESCRIPTION	NO. OF TEETH	SPEED RATIO (CRANKSHAFT: DRIVE)	DIRECTION OF ROTATION (REAR VIEW)
Upper hydraulic pump drive gear	31	1.1.452	Counterclockwise
Propeller governor drive gear	29	1 1 0345	Clockwise
Upper tachometer drive gear	60	1 0 5	Counterclockwise
Generator drive gear	19	1 2.3685	Counterclockwise
Magneto drive gears	20	1.1.5	Clockwise
Starter jaw	3	1.1	Clockwise
Camshaft gear	60	1 0 5	Counterclockwise
Lower hydraulic pump drive gear	21	1 1 4286	Clockwise
Fuel pump drive gear	32	1 0 9375	Counterclockwise
Fuel pump idler gear	24	1 1 25	Clockwise
Oil pump drive gear	30	1 1	Clockwise
Oil pump driver gear	8	1 1	Clockwise
Oil pump driven gear	8	1 1	Counterclockwise

of the lower left side of the accessory case rear half by two nut locks (2), plain nuts (3), and plain washers (4). An opening in the pad matches the mount flange hole in the spout, permitting oil poured into the neck to enter the case. The oil filler cap assembly (1) is attached by a bayonet locking device, requiring a quarter turn to the right to secure it. A hose nipple (33), sealed by a copper-asbestos gasket (34), is connected by a short hose to a nipple welded into the upper surface of the sump. This provides a passage through which any oil drained into the accessory case can reach the sump. The starter adapter (18) is attached, over a gasket (22), by two nut locks (19), plain nuts (20), and plain washers (21) to a pad machined on the case rear surface and concentric with the crankshaft and its starter jaw. The adapter is a magnesium casting with an open center to admit the starter dog and clutch. Six starter attaching studs pass through adapter holes and project to rear of adapter's starter mount pad.

1 PLAIN NUT
2 PLAIN WASHER
3 GASKET
4 NUT LOCK
5 PLAIN NUT
6 PLAIN WASHER
7 GASKET
8 STUD
9 GENERATOR DRIVE BUSHING
10 GENERATOR ADAPTER
11 PIPE PLUG
12 PIPE PLUG
13 UPPER TACHOMETER DRIVE FRONT BUSHING
14 PROPELLER GOVERNOR DRIVE FRONT BUSHING
15 LOWER HYDRAULIC PUMP DRIVE FRONT BUSHING
16 UPPER HYDRAULIC PUMP DRIVE FRONT BUSHING
17 BUSHING RETAINING PIN
18 MAGNETO DRIVE FRONT BUSHING
19 STEEL DOWEL
20 STEEL DOWEL
21 STUD
22 STUD
23 STUD
*24 STUD
†25 BOLT STUD
26 STUD
27 STUD
28 ACCESSORY CASE FRONT HALF
29 NUT LOCK
30 PLAIN NUT
31 PLAIN WASHER
32 GASKET
33 MAGNETO ADAPTER BUSHING
34 LEFT MAGNETO ADAPTER
35 PIPE PLUG
36 PIPE PLUG
37 PIPE PLUG
38 PIPE PLUG
39 PIPE PLUG
40 PIPE PLUG
†41 SPECIAL HEX HEAD PLUG
†42 COPPER-ASBESTOS GASKET
43 PROPELLER GOVERNOR DRIVE REAR BUSHING
44 OIL PUMP DRIVE BUSHING
45 FUEL PUMP IDLER BUSHING
46 UPPER TACHOMETER DRIVE REAR BUSHING
47 LOWER TACHOMETER DRIVE REAR BUSHING
48 OIL PUMP DRIVEN GEAR BUSHING
49 FUEL PUMP DRIVE BUSHING
50 UPPER HYDRAULIC PUMP DRIVE REAR BUSHING
51 LOWER HYDRAULIC PUMP DRIVE REAR BUSHING
52 STEEL DOWEL
53 STEEL DOWEL
54 STUD
55 STUD
56 STUD
57 STUD
58 BOLT STUD
59 STUD
60 STUD
61 STUD
62 STUD
63 STUD
64 STUD
65 STUD
66 STUD
67 ACCESSORY CASE REAR HALF

Figure 2–4 View of Accessory Case Front and Rear Machining Assembly (Sheet 1 of 2)

TABLE II. ACCESSORY DRIVE DATA

ACCESSORY	DRIVE TYPE	DRAWING NO	DRIVE MEMBER	ROTATION*	MAXIMUM RPM
Starter	XIV-A	AND 20004	3 Jaws	Clockwise	8C
Generator	XII-A	AND 20002	16 Splines	Clockwise	6162
Propeller governor	XX	AND 20010	12 Splines	Clockwise	2678
Upper hydraulic pump	XI-A	AND 20001	12 Splines	Clockwise	3770
Lower hydraulic pump	X	AND 20000	12 Splines	Clockwise	3715
Magnetos	Special	———	Slot	Clockwise	3900
Fuel pump	XIII-A	AND 20003	11 Splines	Counterclockwise	2444
Oil pump	Special	———	13 Splines	Clockwise	2600
Tachometer generator	XV-A	AND 20005	1/4-inch square hole	Counterclockwise	1300

*Direction of rotation as observed when facing accessory mount pad.

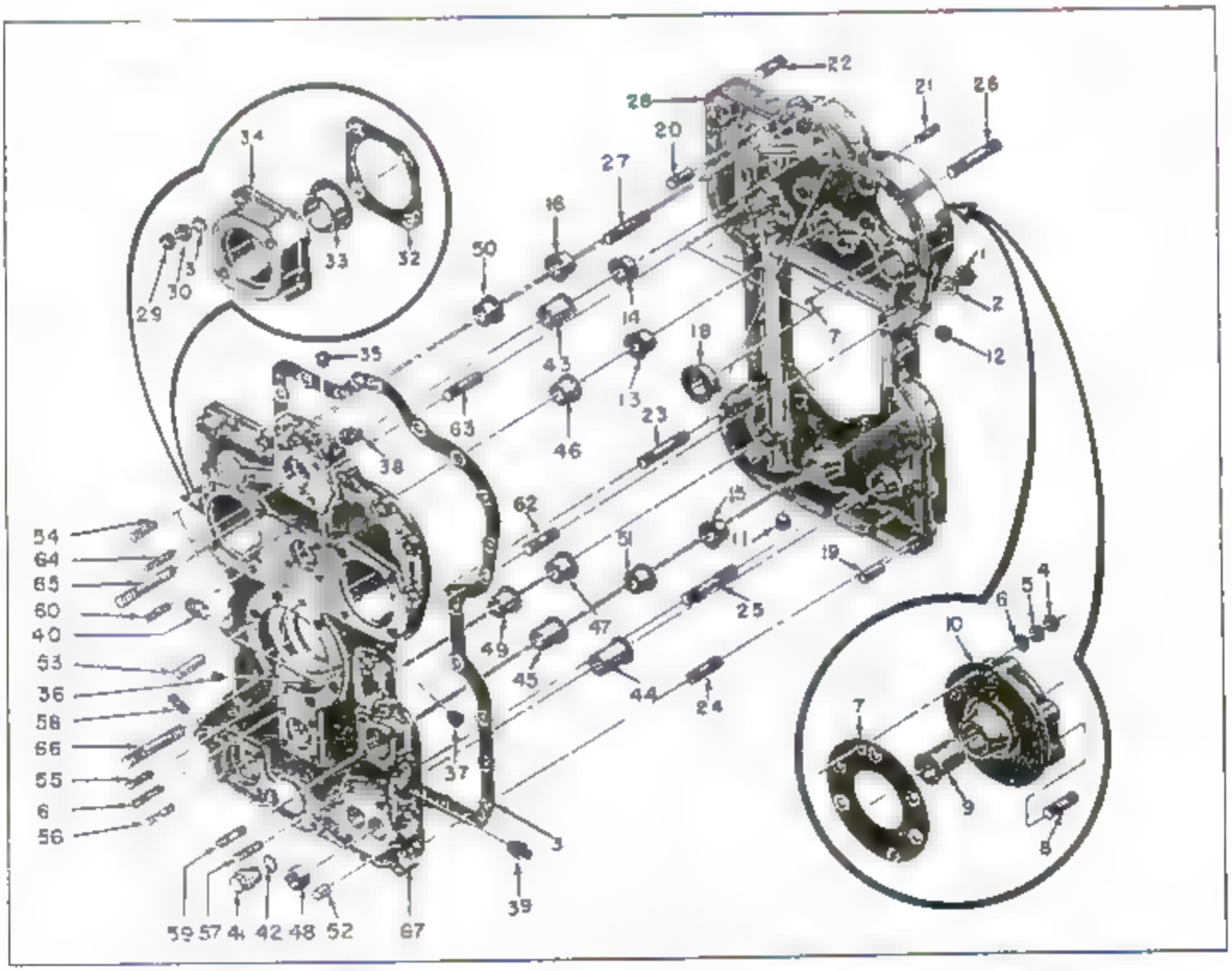


Figure 2–4 View of Accessory Case Front and Rear Machining Assembly (Sheet 2 of 2)

2–39 GEARS AND BUSHING PLUGS. (See figure 2–3.) Each magneto cluster gear assembly consists of a magneto drive shaft gear (83), a magneto drive gear (82), and a magneto drive gear sleeve (81). The small gear and external splines are machined and ground in the shaft and the rear shaft end is slotted to receive the magneto drive coupling. The second gear is internally splined and pressed permanently on the shaft splines before its teeth are finish ground. The steel sleeve is pressed into the slotted shaft end to help retain the rubber coupling bushings. The upper tachometer drive gear (60) is bored through the shaft. An oil plug (59) is pressed in the front end of the bore. The same construction is used in the lower hydraulic pump drive gear (62) and oil plug (61), and the fuel pump drive gear (66) and oil plug (65). No oil plug is required in the fuel pump idle gear (64), whose bearing is blind, or in the oil pump drive gear (63). When no shaft is installed in the lower tachometer drive bushing, lower tachometer drive plug (70) is substituted. The plug is retained by a Truarc external snap ring (69). Aluminum plugs (67 and 68) also replace the upper hydraulic pump drive gear and the propeller governor drive gear when these gears are not installed. The three bushing plugs prevent oil, fed to the bushings under pressure, from escaping freely into the accessory case and reducing oil pressure below the required value. The construction of the generator drive gear (80) and its oil plug (79) is similar to that of the fuel and hydraulic pump drive gears. The generator drive gear is retained in its adapter by a Truarc external snap ring (77) which fits into a groove in the gear shaft and is separated from the bushing end by an aluminum thrust washer (78).

2–40. OIL SEALS. (See figure 2–3.) All rotating shafts which are open to the exterior of the accessory case are sealed against oil leakage by steel cased seals with spring compressed rubber sealing members whose lips ride on the polished rotating parts. The seal assemblies are pressed into accessory case counterbores surrounding the shafts and just inside the larger counterbores for accessory pilots, if any. The starter jaw oil seal (71) rides on the periphery of the jaw attached to the crankshaft. Inside the oil seal positions are smaller recesses with drilled vent and oil drain holes leading to the interior of the case.

2–41. MACHINING AND STUDDING ASSEMBLIES. (See figure 2–4.) The accessory case front half (28) machining and studding assembly is composed of the magnesium casting, its studs, bushings, pipe plugs and dowels, the generator adapter assembly, and its attaching parts (4, 5, 6, and 7). The generator adapter assembly consists of the generator adapter (10), generator drive bushing (9) and the bottom stud (8) of six which attach the generator. The other five generator attaching studs (26) are driven in tapped holes in the adapter mount pad of the case and project forward through adapter holes and beyond the generator mount pad. The adapter is attached to two case studs (21). Four studs (22) are driven into tapped holes of the upper hydraulic pump pad to attach a pump or cover. One long stud (25), two long studs (23) and 14 shorter studs (24) are driven into tapped holes in the front half parting flange for attachment of the two halves. Steel dowels (19 and 20) are pressed into front half parting flange holes that fit closely in matching holes of the rear half casting to align the two halves of the case. Flanged bronze bushings (13, 14, 15, 16, and 18) are pressed into bored and oil grooved bosses of the front half. The boss oil grooves are fed by a network of drilled holes, and the bushing walls are drilled through to admit oil to the bearing surfaces. The accessory case rear half machining and studding assembly is composed of the accessory case rear half (67), its studs, bushings, pipe plugs and dowels, two cast magnesium magneto adapter assemblies and their attaching parts (29, 30, 31, and 32). The front half machining and studding assembly is sealed to the rear half assembly by a gasket (3) and the two halves are attached for shipment by two plain washers (2) and plain nuts (1). These assemblies and attaching parts constitute the accessory case front and rear machining assembly. Nut locks (44, figure 2–3) are not supplied with this assembly as a spare part, nor are attaching parts in figure 2–3 numbered 35, 36, 37, 38, 39, 40, 41, 42, and 43, though these parts are installed when the complete case is built up. The last named attaching parts are installed on studs of the front half assembly which project through rear half bosses of various depths. In figure 2–4, attaching parts numbered 1 and 2 are installed on studs (62 and 63) which are driven in the parting flange of the rear half. Bushings installed in the rear half are similar to those in the front half and are drilled to receive oil from case grooves connected by an upper and a lower network of drilled holes. Magneto and generator adapter bushings are also drilled for lubrication and the adapters are grooved and drilled to receive oil from the case passages. The magneto adapter assemblies are composed of adapters (34) and bushings (33). These assemblies and the generator adapter assembly are installed before their bushings are finish bored. This is necessary in order to line bore front and rear magneto gear bushings and to bore these and the generator adapter bushing at the correct distances from other bushings to maintain the correct gear spacing and backlash.

2–42. OIL PUMP.

2–43. The oil pump and oil screen body (29, figure 2–5) encloses the pumping gears, the oil pressure relief valve assembly, and the pressure oil screen. The pump is attached to six studs driven in its mount pad (at the lower right corner of the accessory case rear side) by plain washers (12), plain nuts (11), and nut locks (10). The housing parting flange is lapped flat, and no gasket is used in the joint. The driver gear (9) and the driven gear (8) fit closely in a chamber bored in the front, or flange side, of the housing. Their rear

stud shafts bear in gear bushings (28) pressed into holes bored beyond the gear chamber and in line with accessory case bushings in which the front shafts are borne, leaving a small clearance around the teeth. Two dowels driven into holes in the pump mount pad fit closely in pump housing holes to maintain alignment of the oil pumping gear bushings in the housing with gear bushings in the accessory case. Oil is admitted to the pumping chamber inlet port through a hose adapter (7), which is connected by a one inch ID hose to the suction tube assembly in the sump. The pump discharges into the screen chamber at the top of the housing through a cored passage. The pressure oil screen assembly (16), is screwed into the screen chamber opening and is sealed by a copper-asbestos gasket (17). The ferrule at the inner end of the screen fits closely in a counterbore of the housing surrounding a cored passage to the discharge port and downward to the relief valve seat bore. The relief valve plunger (26) slides in a sleeve (27) below the screen chamber. The sleeve is held against its cone seat by a spring (24) which seats inside the adjusting screw. An inner spring (25), seated inside a bushing in the screw, tends to hold the plunger (26) in a position covering a side relief hole in the sleeve. The screw is turned into the housing thread part way to compress the springs. On its protruding threads are installed a copper-asbestos gasket (22), a hex lock nut (21), another copper-asbestos gasket (20), and a relief valve cap (19) in that order. A cored housing passage back to the pump inlet is opened whenever the force of oil on the valve plunger end overcomes the inner spring and pushes the plunger back enough to uncover the side relief hole. A flared tube and pipe elbow (6) is screwed into the pump housing discharge port, and to it is connected a hose assembly (1) which conducts the discharged oil to the crankcase. The elbow and hose assembly are not parts of the pump assembly, nor is the inlet hose adapter. A hex head plug (14) and a copper-asbestos gasket (15) may be removed from the pressure oil screen cap to install a temperature gage capillary. The splined shaft of the pump driver gear is driven by the oil pump drive gear in the accessory case. (See figures 2–2 and 2–3.)

2–44. CYLINDER COOLING SYSTEM.

2–45. The cylinders are cooled by the flow of air through external head and barrel fins. Baffles which direct the air flow are aircraft parts.

2–46. LUBRICATION SYSTEM.

2–47. TYPE. This is a wet sump pressure and spray system which provides lubrication of all moving parts without manual application of lubricants, other than

1 HOSE ASSEMBLY
2 ELASTIC STOP NUT
3 HEX HEAD BOLT
4 HOSE CLAMP
5 HOSE CLAMP
6 FLARED TUBE AND PIPE ELBOW
7 HOSE ADAPTER
8 OIL PUMP DRIVEN GEAR
9 OIL PUMP DRIVER GEAR
10 NUT LOCK
11 PLAIN NUT
12 PLAIN WASHER
13 LOCK WIRE
14 HEX DRILLED HEAD PLUG
15 COPPER-ASBESTOS GASKET
16 OIL SCREEN ASSEMBLY
17 COPPER-ASBESTOS GASKET
18 LOCK WIRE
19 OIL PRESSURE RELIEF VALVE CAP
20 COPPER-ASBESTOS GASKET
21 LOCK NUT
22 COPPER-ASBESTOS GASKET
23 SCREW AND BUSHING ASSEMBLY
24 OUTER RELIEF VALVE SPRING
25 INNER RELIEF VALVE SPRING
26 RELIEF VALVE PLUNGER
27 RELIEF VALVE SLEEVE
28 OIL PUMP GEAR BUSHING
29 OIL PUMP AND OIL SCREEN BODY

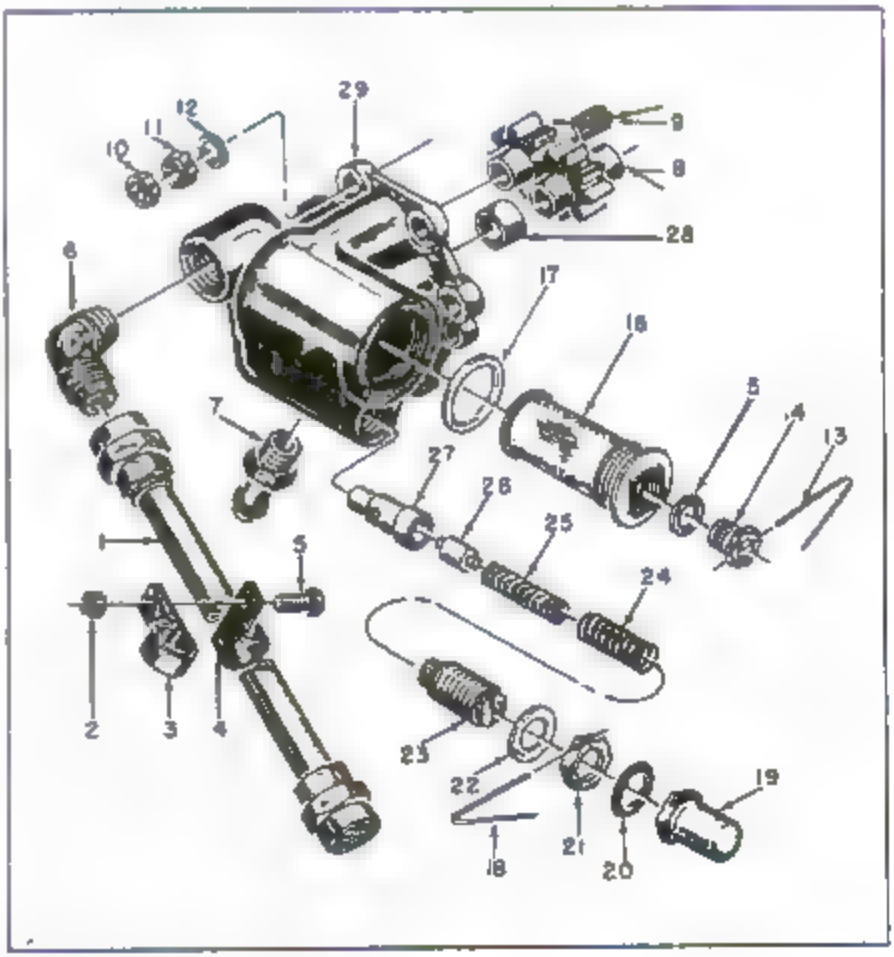
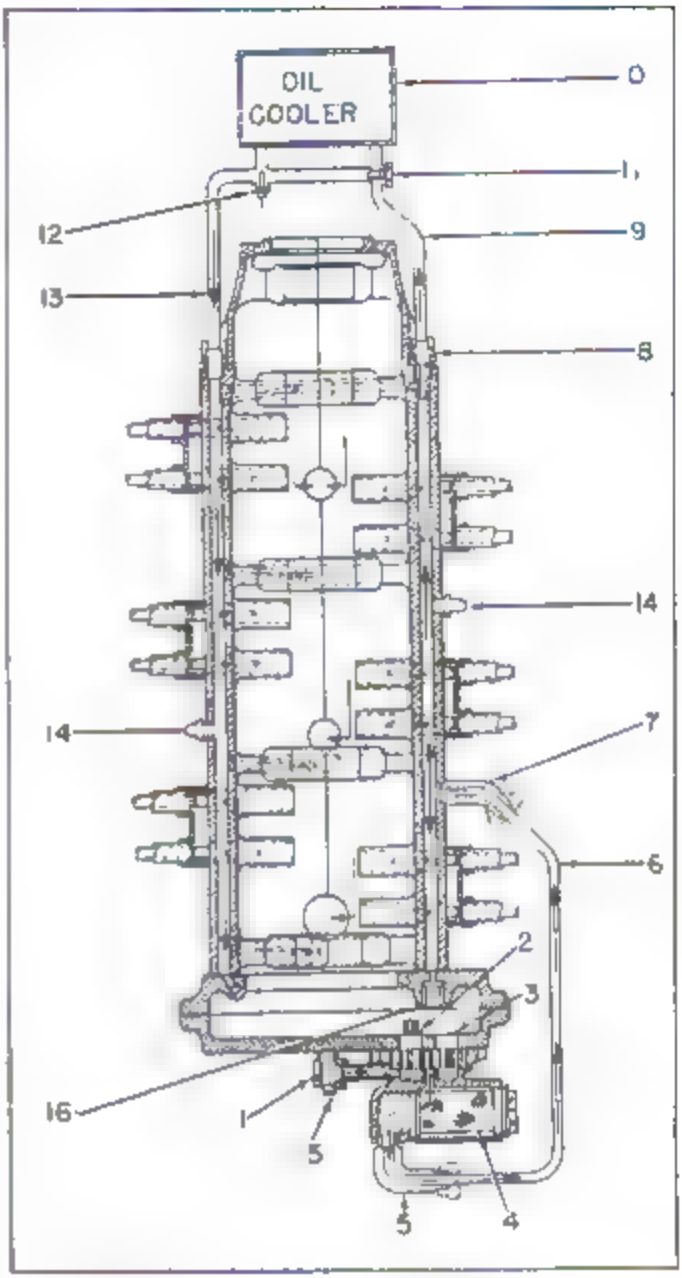


Figure 2–5. View of Oil Pump

periodic replenishment and changing of lubricating oil.

2–48. EXTERNAL PARTS. (See figure 2–6.) The external parts not included in the engine assembly are the oil cooler and its hose connections. A hose adapter (8) is screwed into the front end of the crankcase right oil gallery and sealed by a copper-asbestos gasket. A hose assembly (9) attached to this adapter leads to the oil cooler inlet. The adapter covers and closes off the end of the crankcase cross passage through the front camshaft bearing. A return hose assembly (13) is connected between the oil cooler outlet and a fitting screwed into the front end of the crankcase left oil gallery. The only external parts of the lubrication system supplied with the engine are the hose adapter (8), a hose assembly (6), flared tube and pipe thread elbows (5 and 7), and the oil suction tube assembly (1) and its connecting parts. This is the only type of external oil system employed with the engines, however, the engine is adaptable to other plumbing arrangements. The oil cooler, if its location justifies, can be connected between oil pump and crankcase using the same inlet port at the flared tube and pipe thread elbow (7), or the oil stream can be led from the pump, through the cooler and into the crankcase by using the left side inlet port provided in the crankcase. If an oil cooler is not connected between the front ends of crankcase left and right oil galleries, these openings are closed by screw plugs sealed with copper-asbestos gaskets.

2–49. PRIMARY CIRCULATION. (See figure 2–6.) The oil supply is carried in the sump. The suction tube assembly (1), screwed into a boss at the rear of the sump near the bottom, has a perforated tube extending horizontally into the oil reservoir to admit the oil, while stopping any large particles. The suction tube elbow extends obliquely upward toward the oil pump. A hose connects it to the nipple screwed into the pump housing inlet hole. Atmospheric pressure on the surface of oil in the sump reservoir forces it to flow through the suction tube and connections to the oil pump inlet port to fill the volume displaced by rotation of the oil pump gears (2 and 3). Oil is carried around these gears in the tooth spaces and is discharged into the pressure oil screen chamber. Since the oil screen (4) blocks the exit from its chamber, the oil is forced to pass through its double thickness of wire mesh, depositing any foreign particles on the outer screen surface, in order to reach the passage leading to the discharge port flared tube and pipe thread elbow (5). Discharged oil is forced through the hose assembly (6), flared tube and pipe thread elbow (7) into the crankcase right oil gallery. It flows forward and through the hose adapter (8) and hose assembly (9) to the oil cooler inlet. When oil temperature is low a thermostatic bypass valve (11) is open, allowing the oil stream to bypass the cooler. As oil temperature



1 OIL SUCTION TUBE ASSEMBLY
2 OIL PUMP DRIVER GEAR
3 OIL PUMP DRIVEN GEAR
4 PRESSURE OIL SCREEN
5 FLARED TUBE AND PIPE THREAD ELBOW
6 OIL PUMP TO CRANKCASE HOSE ASSEMBLY
7 FLARED TUBE AND PIPE THREAD ELBOW
8 HOSE ADAPTER
9 OIL COOLER INLET HOSE ASSEMBLY
10 OIL COOLER
11 THERMOSTATIC BYPASS VALVE
12 OIL TEMPERATURE GAGE CAP CAPILLARY
13 OIL RETURN HOSE ASSEMBLY
14 OIL PRESSURE GAGE CONNECTION
15 OIL DILUTION CONNECTION PLUG
16 LOWER HYDRAULIC PUMP DRIVE FRONT BUSHING

Figure 2–6. Lubrication System Diagram

rises the valve closes, forcing an increasing portion of the oil through the cooler core. From the oil cooler outlet, the oil stream is led through a hose assembly (13) into the left oil gallery. The rear ends of both crankcase galleries are open and the accessory case lubrication system is supplied from these points.

2–50. OIL PRESSURE REGULATION. An oil pressure relief valve is incorporated in the oil pump. Its seat opens into the discharge passage and its relief opening is connected to the pumping chamber inlet, so that any oil which escapes through the valve passes directly back to the pump and is recirculated. A 1/8-inch pipe tapped hole in the crankcase left oil gallery is used to connect a tube to the oil pressure gage.

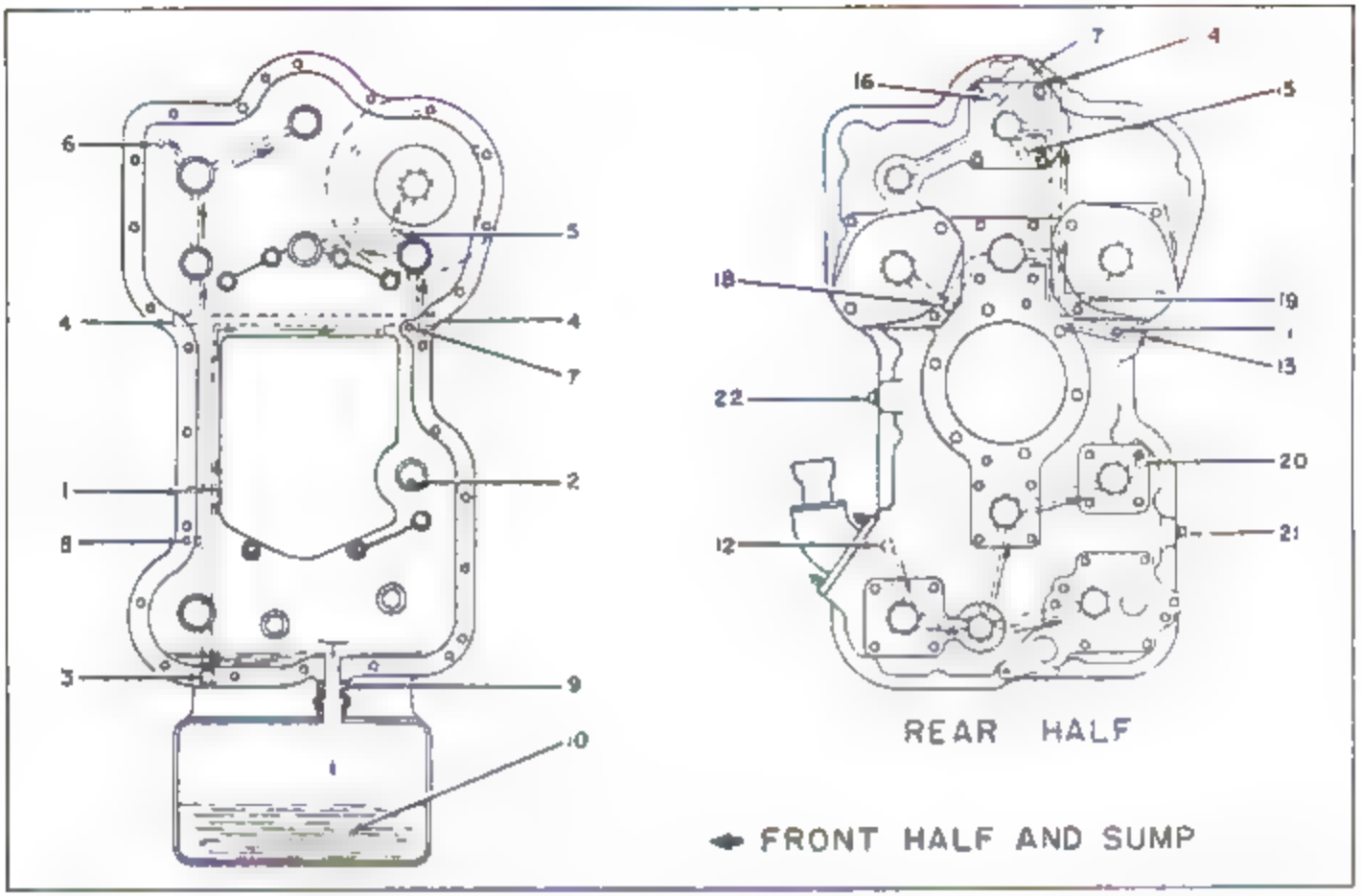
2–51. CRANKCASE, CYLINDER AND VALVE TRAIN LUBRICATION. The oil gallery holes drilled into main bearing seats feed oil to bearing inserts. Drilled holes in the inserts admit oil to the main bearing surfaces. Oil is conducted from the main bearings to crankpins and to the front main thrust bearing. Oil holes admit oil to all camshaft bearings. The system pressure forces oil from all bearing ends and a spray fills the crankcase. Some of the spray enters the cylinders to cool and lubricate. It also lubricates cam lobes and followers.

2–52. CRANKCASE DRAINAGE. The oil drains through three holes. The rear drain hole is connected directly to the oil sump by the sump's upper inlet tube, which is sealed in the hole by an "O" ring hydraulic packing. The front and center crankcase drain holes are centered in the mount pads on the crankcase bottom surface for the intake and oil drain manifold. Since no front oil drain tube is used in this assembly, the manifold's front mount boss bottom pad is covered by a plate, so that all oil entering the manifold oil passage at front and rear passes through the rear outlet and its hose connection to the sump front inlet tube.

2–53. ACCESSORY DRIVE LUBRICATION. (See figure 2–7.) Oil from the crankcase left gallery is forced into an oil inlet (1) drilled from the accessory case front half front parting flange to intersect a vertical hole drilled from the bottom of the case into a horizontal oil hole above the gear aperture. Pipe plugs (3 and 4) close the vertical and horizontal passages at the surfaces of the front half casting. A small oil inlet (2), drilled from the blind front end of the lower hydraulic pump gear front bushing recess forward to the front parting flange, admits oil from the crankcase right oil gallery to the gear bearing surface. A network of oil passages drilled in bosses of the front half casting connects the main feed holes to grooves machined around gear bushing bores. The bushing walls are drilled to admit oil to their bearing surfaces. Oil outlets (5 and 6) drilled from the generator adapter mount pad and the upper hydraulic pump pad, respectively, into bushing oil grooves supply oil to the generator adapter, which is drilled into its gear bushing bore, and to the hydraulic pump, when one is installed, to lubricate its rotor. Oil outlets (7 and 8), drilled from the front half rear parting flange into the main oil passages conduct a portion of the oil stream to matching oil inlets (11 and 12) drilled from the accessory case rear half parting flange into the rear half upper and lower lubrication networks, respectively. Pipe plugs (13 and 14) close ends of the upper rear network main passage of the case surfaces. An oil outlet (15), drilled from the propeller governor pad into the gear bushing oil groove, supplies oil to the governor valve and boost pump for actuation of a hydraulic controllable propeller when a governor is installed. The oil delivered by the governor enters an oil inlet (16) in the mount pad and passes out through an intersecting case hole to a fitting and tube and thence to the propeller hub inlet. When no governor is installed, its drive gear bushings are closed against oil leakage by an aluminum plug and oil outlets (15 and 16) are closed by a mount pad cover. Likewise, the upper hydraulic pump gear bushings and oil outlet (6) are closed off when no pump is installed there. The propeller oil supply passage, when not used, is closed by a pipe plug (17). Oil outlets (18 and 19), drilled from their mount pads into the upper rear lubrication network, supply oil to the left and right magneto adapters, respectively. Magneto adapters are drilled to provide oil passages from mount pad holes to grooves surrounding their cluster gear bushings. The lower hydraulic pump is lubricated by oil supplied through an oil outlet (20) from its mount pad to its drive gear bushing groove.

2–54. ACCESSORY CASE OIL SEALS AND DRAINS. (See figure 2–7.) With the exceptions of the propeller governor drive, magneto drives and the oil pump drive, all accessory drives are equipped with steel cased rubber oil seals which are pressed into accessory case recesses outside the gear bushings so that their sealing lips ride on the drive shafts where they emerge and stop any oil from escaping. The drives mentioned above do not require oil seals, since magnetos have their own seals, and the others are subject to oil pressure from the accessories. Where oil seals are installed, vents and drain holes are drilled to the interior of the accessory case to prevent build-up of pressure on sealing lips. Oil drain connections from accessories may be installed in accessory case drain openings otherwise closed by pipe plugs (21 and 22). All accessory and adapter flanges are sealed by soft composition gaskets. The spray of oil from accessory case gear bushings, after lubricating the gear teeth, settles to the bottom of the case and drains back to the sump through an adapter (9) and a hose connector. The adapter, like all other straight thread oil line fittings, is sealed to the case by a copper-asbestos gasket.

2–55. CRANKCASE OIL SEAL. The engine requires a kind of crankshaft oil seal which can be installed



1 OIL INLET FROM CRANKCASE LEFT GALLERY
2 OIL INLET FROM CRANKCASE RIGHT GALLERY
3 PIPE PLUG
4 PIPE PLUG
5 OIL OUTLET IN GENERATOR ADAPTER PAD
6 OIL OUTLET IN UPPER HYDRAULIC PUMP PAD
7 OIL OUTLET TO RIGHT SIDE OF REAR HALF
8 OIL OUTLET TO LEFT SIDE OF REAR HALF
9 HOSE ADAPTER
10 OIL SUCTION TUBE SCREEN
11 OIL INLET FROM FRONT HALF RIGHT SIDE
12 OIL INLET FROM FRONT HALF LEFT SIDE
13 PIPE PLUG
14 PIPE PLUG
15 OIL OUTLET IN PROPELLER GOVERNOR PAD
16 OIL INLET IN PROPELLER GOVERNOR PAD
17 PIPE PLUG
18 OIL OUTLET IN LEFT MAGNETO ADAPTER PAD
19 OIL OUTLET IN RIGHT MAGNETO ADAPTER PAD
20 OIL OUTLET IN LOWER HYDRAULIC PUMP PAD
21 PIPE PLUG
22 PIPE PLUG

Figure 2-7. Accessory Case Oil Passages (Rear View)

in the crankcase front opening by spreading and passing around the crankshaft. A split rubber composition seal is used, the split being located near the top of the seal ring. A helical spring with end loops is hooked to form an elastic compressive ring and lies in a groove in the rear side of the seal, holding the sealing lip to the crankshaft. A felt washer on the exposed face of the rubber seal ring prevents grit from working under the lip and scoring the shaft. This assembly fits tightly in the crankcase opening.

SECTION III

SPECIAL OVERHAUL TOOLS

3–1. GENERAL

3–2. The approved special overhaul tools for performing the dismantling, disassembly, inspection, repair, replacement, testing, and assembly described in this technical manual are listed in Table III. The tools are listed in functional groups based upon the equipment parts to which the tools are applicable, figures 3–1 through 3–6 illustrate special overhaul tools which are referenced in Table III

3–3. A numerical index, in order of tool numbers, is included following Table III. This index shows all group numbers in which each tool appears.

TABLE III. FUNCTIONAL TOOL LIST

GROUP NUMBER	FUNCTION	TOOL NOMENCLATURE	TOOL NUMBER	FIGURE NUMBER	NOTES
1	Accessory Case				
		Tap Set, Oversize	KMO-656	3–4	Index 7
2	Camshaft				
		Gage, Cam bearing	J-2844	3–5	Index 2
3	Connecting Rod and Crankshaft				
		Gage, Connecting rod bushing	J-2854-1	3–5	Index 6
		Gage, Valve lifter bearing	J-2859	3–4	Index 1
		Reamer, Connecting rod bushing	J-5008	3–2	Index 3
		Remover and Replacer, Connecting rod bushing	J-2879	3–4	Index 6
		Holder, Crankshaft assembly	J-2885	3–4	Index 3
4	Cylinder				
		Wrench, Cylinder base nut	J-2882	3–1	Index 4
		Fixture, Cylinder and valve holding	J-2858	3–1	Index 2
		Gage, Cylinder head rocker shaft bore	J-2860	3–4	Index 2
		Fixture, Cylinder head holding	J-2861	3–1	Index 3
		Reamer Set, Rocker shaft support boss	J-5129	3–3	Index 1
		Reamer, Rocker shaft support boss, first cut	J-5129-1	3–3	Index 1

TABLE III. FUNCTIONAL TOOL LIST (CONT)

GROUP NUMBER	FUNCTION	TOOL NOMENCLATURE	TOOL NUMBER	FIGURE NUMBER	NOTES
		Reamer, Rocker shaft support boss, second cut	J-5129-2	3–3	Index 1
		Reamer, Rocker shaft support boss, third cut	J-5129-3	3–3	Index 1
		Kit, Cloth	J-5129-4	3–3	Index 1
		Remover and Replacer	J-5007	None	
		Reamer, Rocker shaft bushing	J-5130	3–3	Index 2
		Drill and Guide Set, Cylinder head fin repair	J-2856	3–5	Index 9
		Broach, Cylinder head valve guide hole, 0.005 inch oversize	J-2846	3–4	Index 4
		Broach, Cylinder head valve guide hole, 0.010 inch oversize	J-7201	3–4	Index 4
		Broach, Cylinder head valve guide hole, 0.015 inch oversize	J-7202	3–4	Index 4
5	Piston				
		Gage, Piston pin hole (Standard)	J-2853-1	3–5	Index 7
		Gage, Piston ring	J-2850	3–1	Index 1
		Gage, Connecting rod bushing	J-2854-1	3–5	Index 6
		Compressor, Piston ring	J-2839	None	
6	Valve				
		Gage, Valve lifter bearing	J-2859	3–4	Index 1
		Gage, Valve Guide stem hole (Set of two)	J-2848	3–5	Index 1
		Gage, Rocker arm bushing (Set of two)	J-2851	3–5	Index 8
		Gage, Valve seat blueing (Set of two)	J-2887	3–2	Index 1
		Gage, Valve guide stem hole	J-2848-1	3–5	Index 1
		Gage, Valve guide stem hole	J-2848-2	3–5	Index 1
		Gage, Cylinder head rocker shaft bore	J-2860	3–4	Index 2

TABLE III. FUNCTIONAL TOOL LIST (CONT)

GROUP NUMBER	FUNCTION	TOOL NOMENCLATURE	TOOL NUMBER	FIGURE NUMBER	NOTES
		Remover, Valve guide	J-2874	3–2	Index 2
		Reamer, Cylinder head valve guide hole	J-5006-1	None	
		Gage, Cylinder head valve guide bore, 0 005 inch oversize	J-2849-1	3–5	Index 3
		Guide, 0.010 inch oversize	J-5006-2	None	
		Driver, Valve guide installing	J-2842	3–5	Index 4
		Broach, Valve guide stem hole (Set of two)	J-2847	3–4	Index 5
		Remover, Exhaust valve seat	J-2877-1	3–6	Index 2
		Remover, Intake valve seat insert	J-2877-2	3–6	Index 1
		Syringe, Rubber (four ounce capacity)	J-2877-21	3–6	Index 3
		Replacer, Exhaust valve seat insert	J-2888-1	3–6	Index 4
		Replacer, Intake valve seat insert	J-2888-2	3–6	Index 5
		Reamer, Cylinder head rocker shaft bore, 0.005 inch oversize	J-2891	3–2	Index 4
		Remover and Replacer, Rocker arm bushing	J-2881	3–5	Index 5
		Reamer, Rocker arm bushing (Set of two)	J-2892	3–2	Index 5

NUMERICAL INDEX

TOOL NUMBER	TOOL NOMENCLATURE	GROUP NUMBER
J-2839	Compressor, Piston ring	5
J-2842	Driver, Valve guide installing	6
J-2844	Gage, Cam bearing	2
J-2846	Broach, Cylinder head valve guide hole, 0 005 inch oversize	4
J-2847	Broach, Valve guide stem hole (Set of two)	6
J-2848	Gage, Valve guide stem hole (Set of two)	6
J-2848-1	Gage, Valve guide stem hole	6
J-2848-2	Gage, Valve guide stem hole	6
J-2849-1	Gage, Cylinder head valve guide bore, 0 005 inch oversize	6

NUMERICAL INDEX (CONT)

TOOL NUMBER	TOOL NOMENCLATURE	GROUP NUMBER
J-2850	Gage, Piston ring	5
J-2851	Gage, Rocker arm bushing (Set of two)	6
J-2853-1	Gage, Piston pin hole (Standard)	5
J 2854-1	Gage, Connecting rod bushing	3,5
J-2856	Drill and Guide Set, Cylinder head fin repair	4
J-2858	Fixture, Cylinder and valve holding	4
J-2859	Gage, Valve lifter bearing	3,6
J-2860	Gage, Cylinder head rocker shaft bore	4,6
J-2861	Fixture, Cylinder head holding	4
J-2874	Remover, Valve guide	6
J-2877-1	Remover, Exhaust valve seat	6
J-2877-2	Remover, Intake valve seat insert	6
J-2877-21	Syringe, Rubber (four ounce capacity)	6
J-2879	Remover and Replacer, Connecting rod bushing	3
J-2881	Remover and Replacer, Rocker arm bushing	6
J-2882	Wrench, Cylinder base nut	4
J-2885	Holder, Crankshaft assembly	3
J-2887	Gage, Valve seat blueing (Set of two)	6
J-2888-1	Replacer, Exhaust valve seat insert	6
J-2888-2	Replacer, Intake valve seat insert	6
J-2891	Reamer, Cylinder head rocker shaft bore, 0.005 inch oversize	6
J-2892	Reamer, Rocker arm bushing (Set of two)	6
J-5006-1	Reamer, Cylinder head valve guide hole	6
J-5006-2	Guide, 0.010 inch oversize	6
J-5007	Remover and Replacer	4
J-5008	Reamer, Connecting rod bushing	3
J-5129	Reamer Set, Rocker shaft support boss	4
J-5129-1	Reamer, Rocker shaft support boss, first cut	4
J-5129-2	Reamer, Rocker shaft support boss, second cut	4
J-5129-3	Reamer, Rocker shaft support boss, third cut	4
J-5129-4	Kit, Cloth	4
J-5130	Reamer, Rocker shaft bushing	4
J-7201	Broach, Cylinder head valve guide hole, 0.010 inch oversize	4
J-7202	Broach, Cylinder head valve guide hole, 0.015 inch oversize	4
KMO-656	Tap Set, Oversize	1

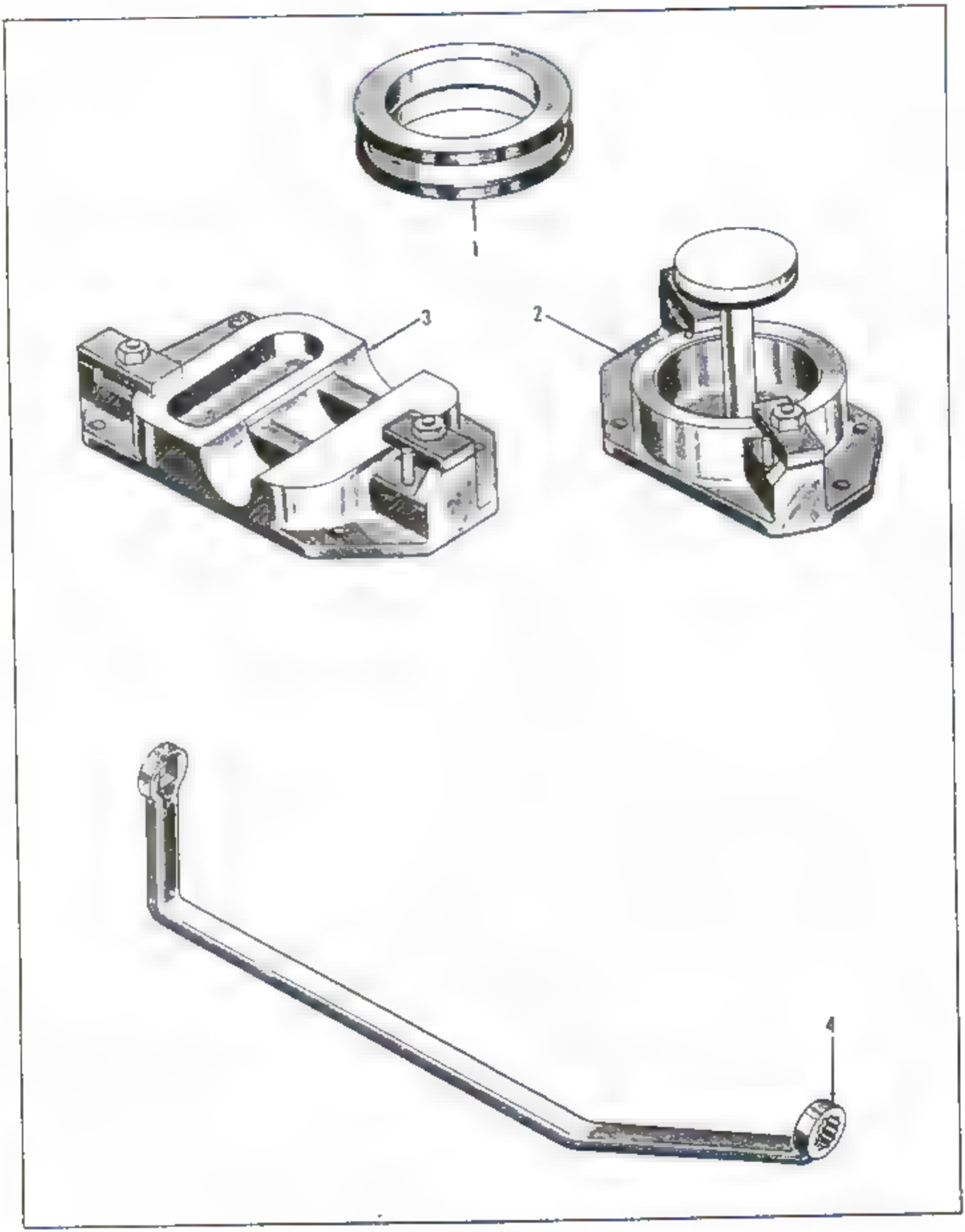


Figure 3–1. Special Tools

Figure 3–2. Special Tools

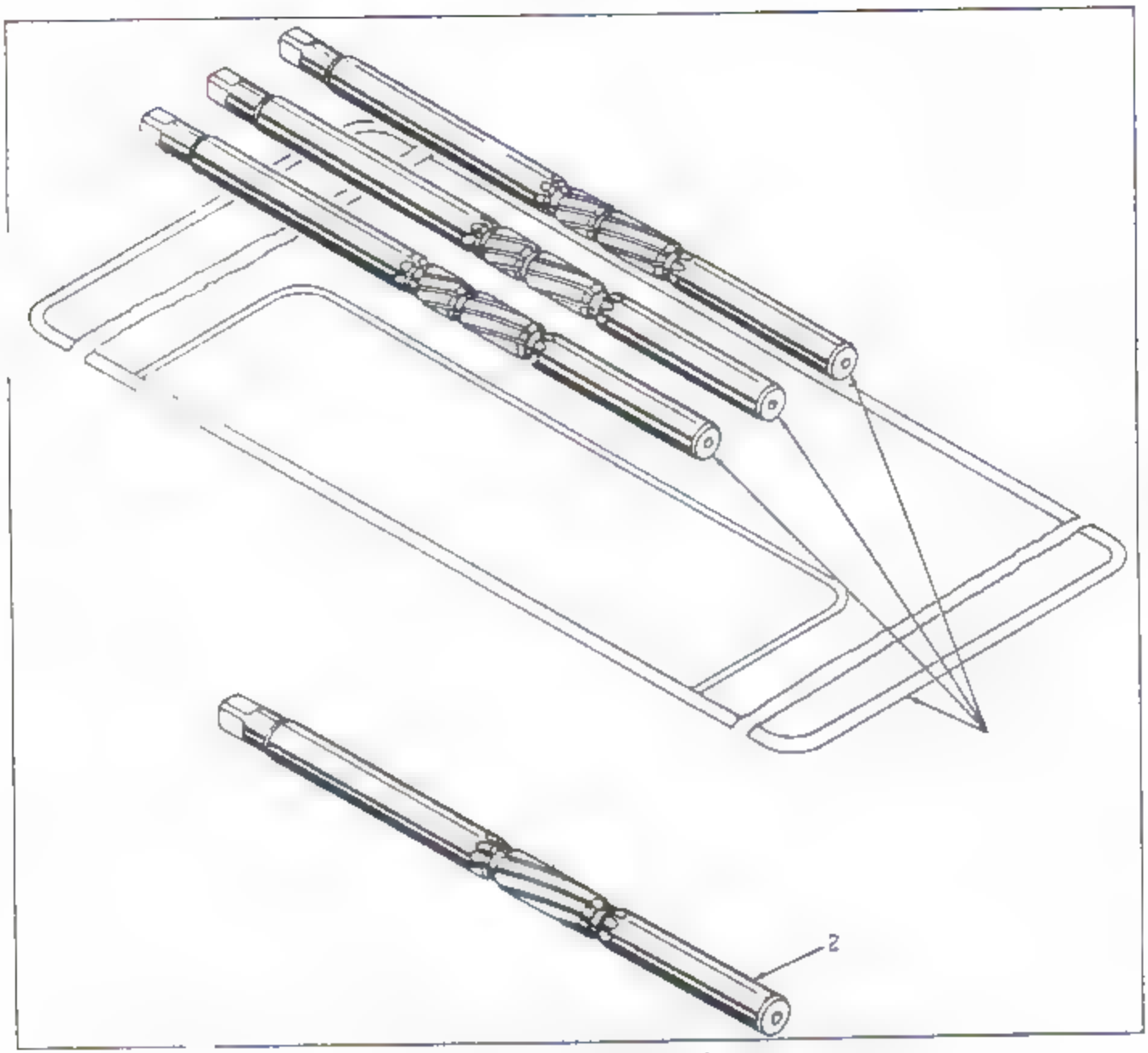


Figure 3-3. Special Tools

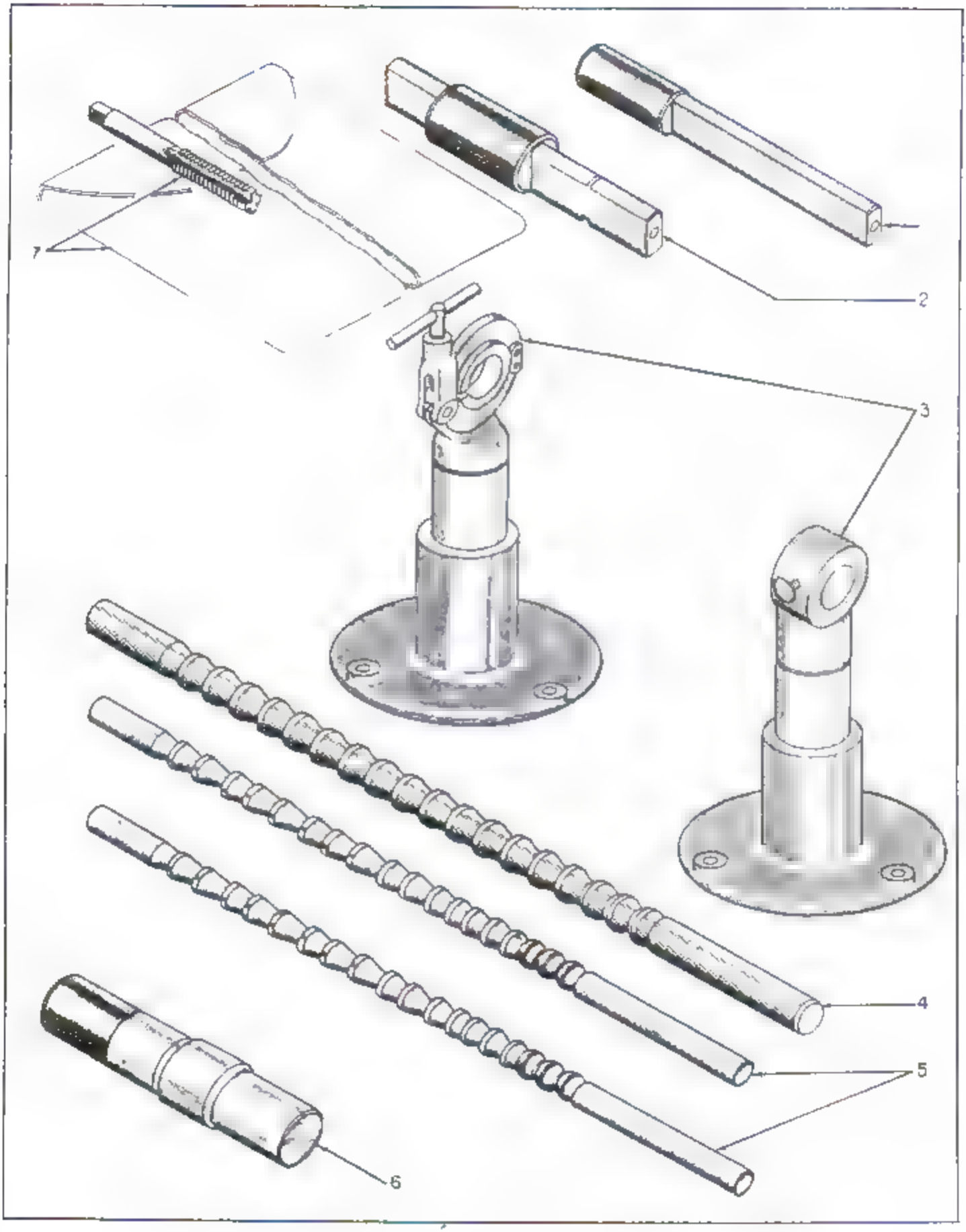


Figure 3–4. Special Tools

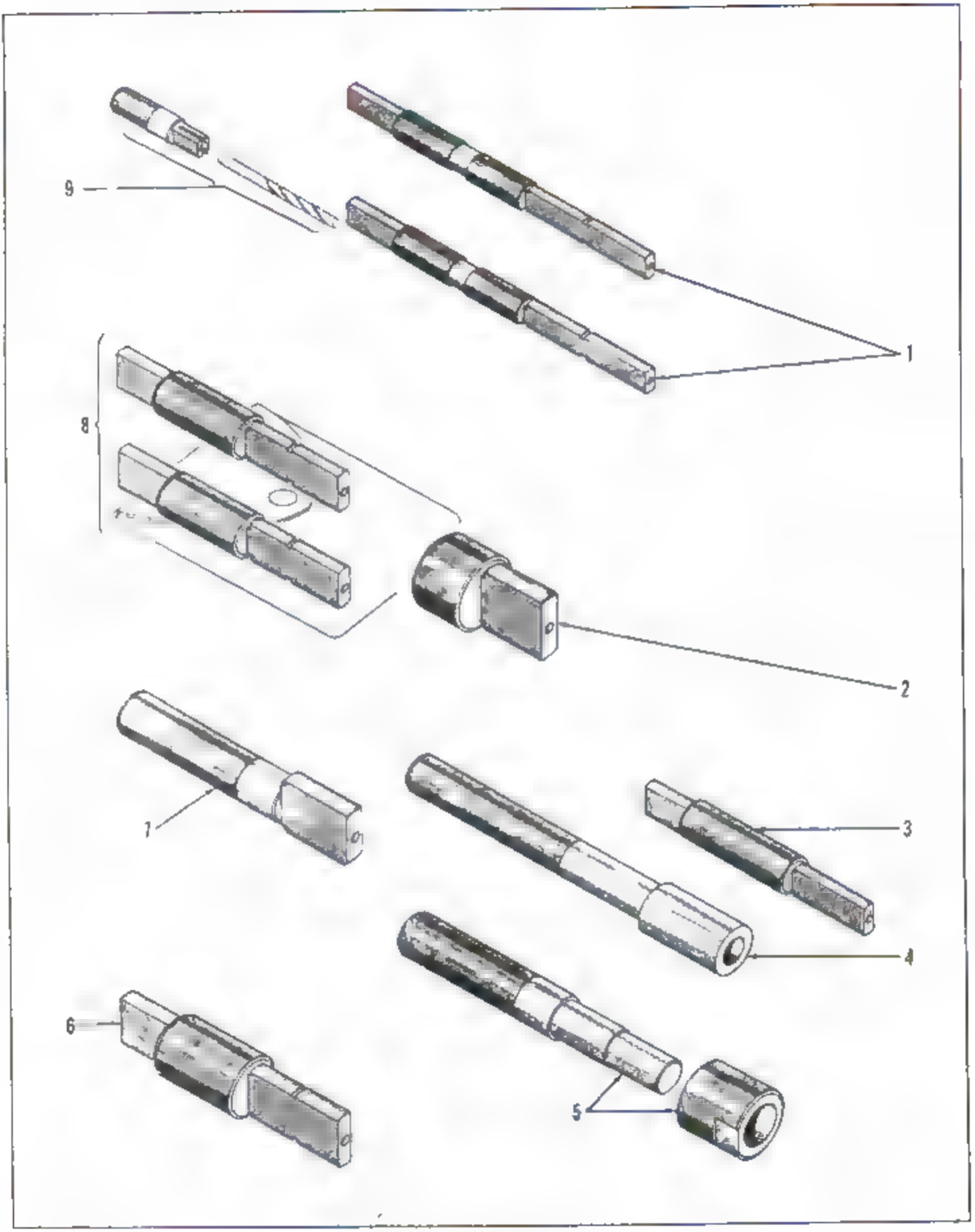


Figure 3–5. Special Tools

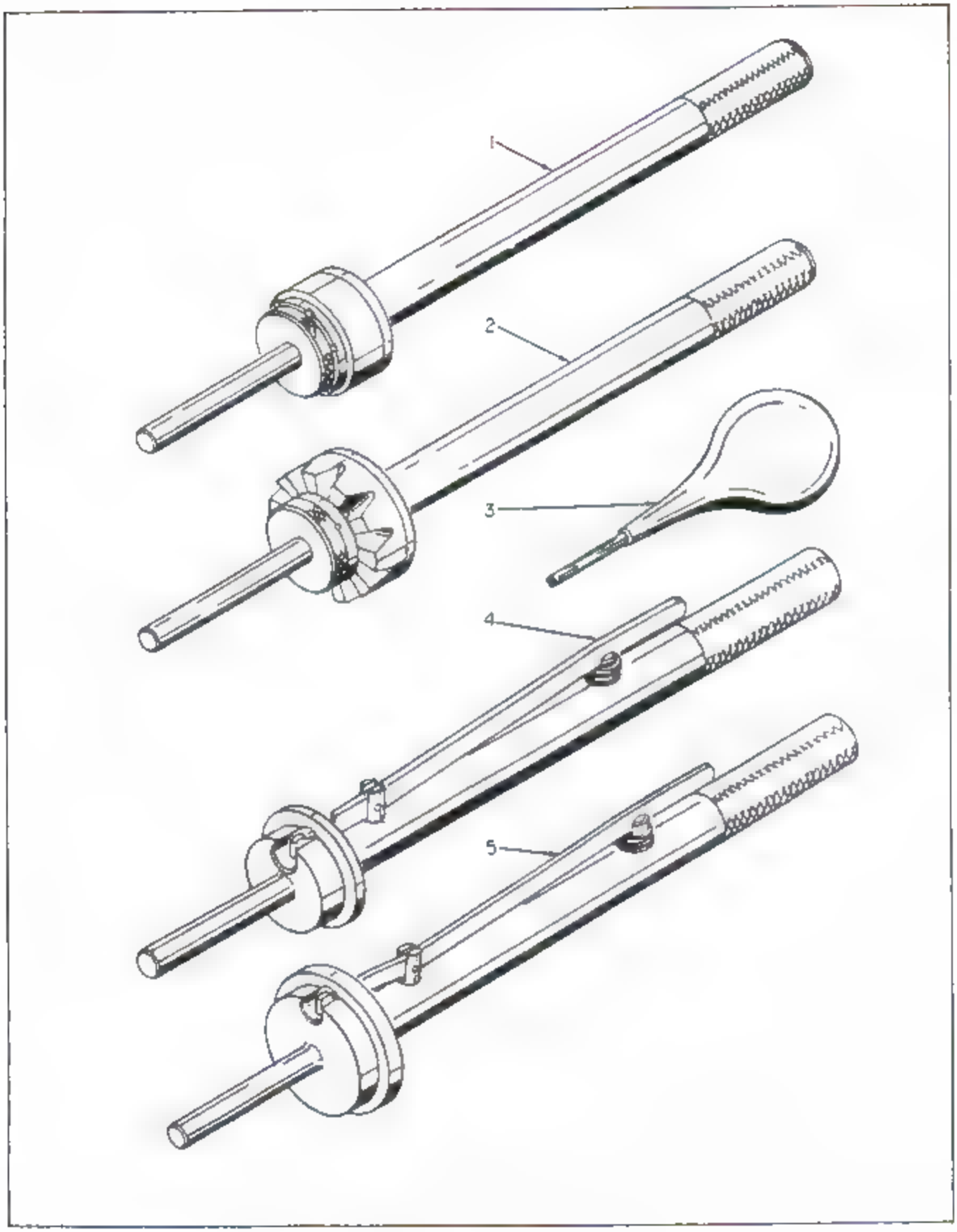


Figure 3–6. Special Tools

SECTION IV

DISMANTLING AND DISASSEMBLY

4–1. REMOVAL OF ENGINE FROM WOOD SHIPPING CRATE.

4–2. Remove the two square head machine screws near the bottom of each side panel. Lift off the top and side panels of the crate in one piece. Remove any wrapping, dehydrating agent, and other material found in the crate base. The engine mount brackets rest on steel plates attached to bolsters of the base assembly. Before removing the attaching bolts, attach a hoist hook to the engine lifting eye. If the hook will not enter the eye, a hook of 1/2-inch round steel bar stock may be forged in such a shape as to hook through the eye and to form a large ring for attachment of the hoist. Take up the weight of the engine on the hoist without lifting it. Remove the four bolts which attach the engine mount brackets to the crate base plates. When lifted from the crate, the engine will balance in a horizontal position, provided that the lifting eye is attached to the fourth and fifth bolts from the rear end of the crankcase upper flange. Hoist the engine and mount it on a suitable assembly stand equipped with brackets to fit the engine mount bracket bushing holes. For convenience and rapid disassembly the stand should have a rotating engine frame which can be locked in such positions as to hold the engine upright – 1, 3, 5, side up – or inverted. Instructions in this section and subsequent sections will assume the use of such an assembly stand.

4–3. REMOVAL OF ENGINE FROM METAL SHIPPING CONTAINER.

4–4. Remove engine from metal shipping containers in the following manner:

a. Remove cover from inspection port.

b. Relieve the air pressure in the container by unscrewing the stem assembly of the air filling valve, located in the inspection port.

c. Remove all closure flange attaching parts and lift off the container upper section with a suitable hoist.

d. Attach a hoist to the engine lifting eye and take up the weight of the engine without lifting it.

e. Loosen nuts on two attaching bolts of each mounting frame adapter bracket enough to permit shifting the brackets without vertical looseness.

f. Loosen and remove the four bolts and eight steel-backed, rubber engine mounts which attach the engine mount brackets to the mounting frame adapter brackets.

g. Hoist the engine out of the container and mount it on a suitable assembly stand.

h. Remove and discard the bags of desiccant and the humidity indicator card from the steel mesh basket inside the inspection port.

i. Loosen and remove the cover from the "engine record" cylinder and pull out any engine records that may be inserted. Attach the records to the engine. Replace the cover.

j. Leave rubber mounts and bolts in the container. Reinstall the inspection port cover and the container upper section.

4–5. PRELIMINARY CLEANING.

4–6. Before proceeding with dismantling, it is advisable to clean thoroughly the exterior of the engine. Pay particular attention to removal of caked dirt and oil from nuts, screw heads and other attaching parts which must be loosened by the use of wrenches and screw drivers. Cleaning may be accomplished by spraying in the manner specified in TM 1-2R-1-84.

4–7. DISASSEMBLY INSPECTION.

4–8. During each stage of disassembly, examine all parts and assemblies for scoring or burning. Look for indications of work incorrectly performed during any previous overhauls. Report any such indications in accordance with current practice.

4–9. PARTS TO BE DISCARDED.

4–10. Unless all, or specific, parts of a particular engine are to be held for special inspection, discard the gaskets – both soft composition and copper-asbestos types – lockwire, nut locks, self-locking nuts, lockwashers, "O" rings, oil seals, rubber seal rings, cylinder base packings, hose connectors, tab washers, and cotter pins as they are removed. These parts must not be mixed with new parts of similar types and must not be used again.

4–11. DISMANTLING.

4–12. STARTER. Remove the nut locks from the six

starter attaching studs; then loosen and run off the six plain hex retaining nuts. Pull the starter straight rearward after breaking loose its gasket. The adapter casting will remain attached to the accessory case.

4–13. GENERATOR. Remove the three self-locking nuts in recesses of the generator adapter, which attach it to accessory case studs. Tap the generator, if necessary, to break the gasket joint, and pull the generator and drive assembly forward to clear the case.

4–14. TACHOMETER GENERATOR. Remove nut locks from the four studs, then loosen and remove the four plain hex nuts which retain the tachometer generator on its mount pad above the starter adapter. Remove the plain washers, and withdraw the generator rearward.

4–15. VACUUM PUMP. Release the pump mounting flange by removing attaching parts from the accessory case studs. (See 5, figure 4–1.) Withdraw the pump to the rear, and peel off its gasket.

4–16. IGNITION SYSTEM.

a. Remove the sleeve clamp from conduits crossing behind the magnetos.

b. Detach the lower spark plug cable conduit brackets from crankcase studs.

c. Remove the four fillister head screws which attach each cable outlet plate to a magneto.

d. Pull the outlet plates and rubber grommets carefully from the magnetos.

e. Loosen and unscrew the spark plug elbow hex coupling nuts, then withdraw the cable contact sleeves carefully from all spark plugs.

f. Lift off the upper and lower cable assemblies separately, taking care to avoid damage to spark plug contacts.

g. Remove nut locks from the four magneto attaching studs, then loosen and remove the plain hex retaining nuts. Remove the four special washers. Bump each magneto to loosen its gasket, then withdraw it rearward from the accessory case.

h. Remove the rubber drive bushings and retainers from the magneto cluster gears, but do not detach the magneto adapters.

i. Loosen all 12 spark plugs with a suitable deep socket and 1/2-inch square drive wrench; then unscrew them by hand.

4–17. PRIMING SYSTEM. Remove cylinder head priming system in the following manner:

a. Detach brackets and clamps from the priming tubes by loosening the two screws on each clamp with a screw driver and removing screws and speed nuts.

b. Loosen all priming tube union nuts with an open end wrench. Unscrew them from priming jets and distributor nipples to free the tubes.

c. Loosen all six primer distributor union nipples with an open end wrench, and back them out of distributor ports. Place these parts in a separate container.

d. Loosen all six cylinder head priming jets with an open end wrench, and unscrew them. Store these parts in a separate container.

e. Remove from the crankcase upper flange the nut lock, plain hex nut, washer and bolt which attach the primer distributor, and store the distributor in a safe place. (It is assumed that the hand pump to distributor tube and union nipple remain with the aircraft.)

4–18. OIL SUMP AND OIL HOSE.

a. Remove the magnetic drain plug at the lower rear edge of the sump to drain any remaining oil. Inspect the plug for metallic particles.

b. Remove the elastic stop nut and bolt which attach the oil pump discharge hose clamp to the clamp on the sump side support bracket. Spread and remove the clamps. Loosen and unscrew the two coupling nuts, and remove the hose assembly.

c. Loosen the oil suction tube hose clamps, and slide the hose connector down on the tube to clear the hose adapter in the oil pump.

d. With a suitable open end wrench, loosen the oil suction tube elbow thread. Slide the hose and clamps from the suction tube; then turn the tube assembly out of the sump boss thread, and withdraw its screen tube end.

e. Withdraw the oil gage rod from its support at the left side of the sump neck.

f. Invert the engine, and lock the assembly stand engine bed in this position.

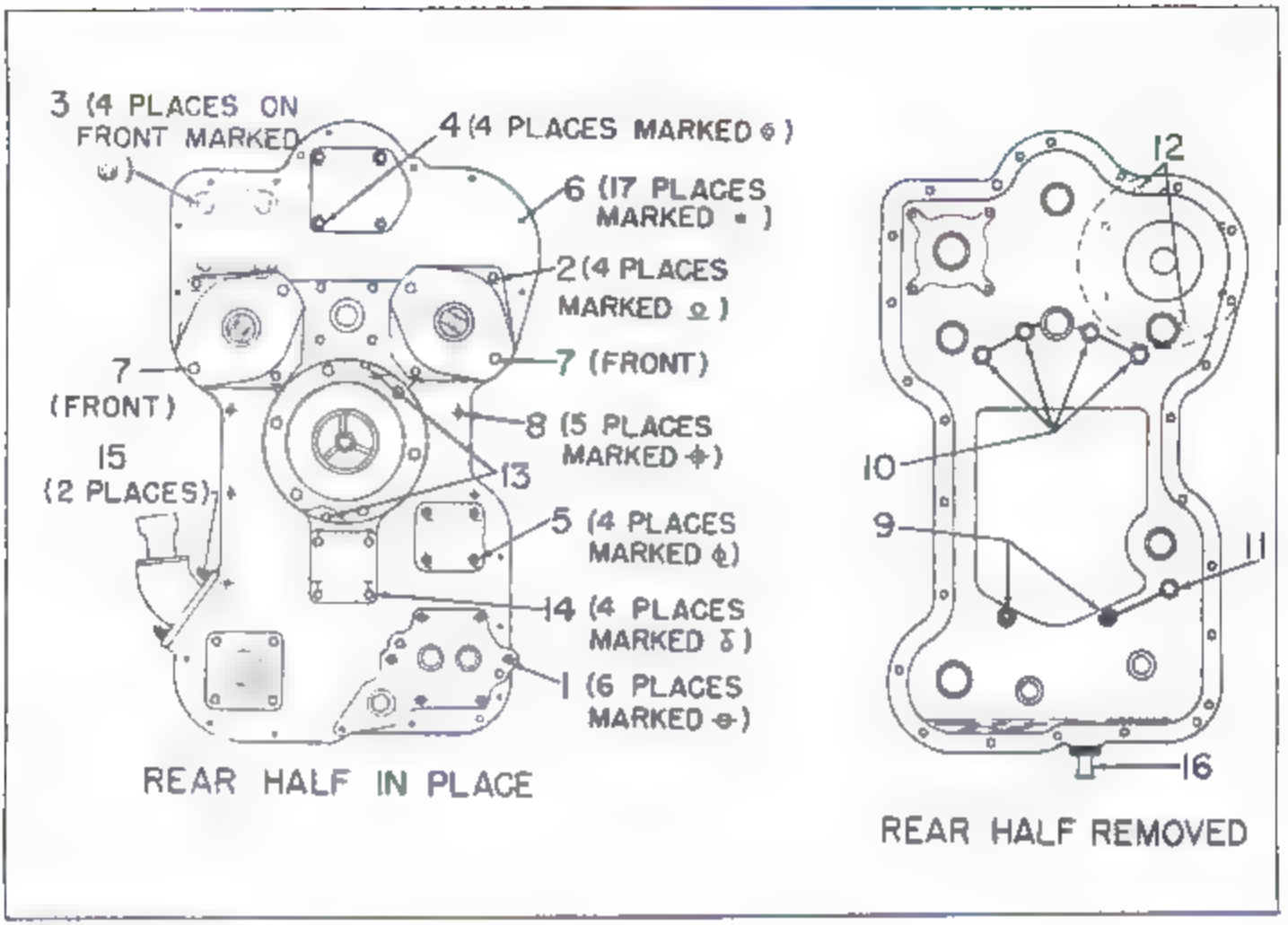
g. Loosen hose clamps on the hoses which connect the sump inlets to the accessory case drain nipple and to the intake and oil drain manifold. Slide the hoses toward the sump.

h. Loosen and remove the left rear manifold attaching bolt to free the upper end of the sump front support bracket.

i. Remove hex head screws, nut locks, nuts, and washers which attach the sump side support brackets to the sump and to the rear engine mount brackets, and lay the support brackets aside.

j. Remove nut locks from the six sump mount bracket attaching studs. Loosen and remove the six retaining nuts, and remove their plain washers.

k. Lift the sump assembly straight upward, rocking it slightly, if necessary, until the upper inlet tube is clear of the crankcase hole; then lay the sump right side up on a bench and remove its front support bracket.



Index No.	Location	Attaching Parts	Qty
1	Oil pump pad studs	Nut lock, plain nut, washer	6 each
2	Magneto adapter retaining studs	Nut lock, plain nut, washer	4 each
3	Upper hydraulic pump pad studs	Nut lock, plain nut, washer	4 each
4	Propeller governor pad studs	Nut lock, plain nut, washer	4 each
5	Lower hydraulic pump pad studs	Nut lock, plain nut, washer	4 each
6	Accessory case front half parting flange studs	Nut lock, plain nut, washer	17 each
7	Accessory case rear half parting flange studs	Nut lock, plain nut, washer	2 each
8	Crankcase studs	Lock, plain nut, washer	5 each
9	Crankcase studs	Cotter pin, castle nut, washer	2 each
10	Crankcase Helicoils	Lock wire, hex head bolt, washer	3 each
11	Crankcase Helicoils	Hex head bolt, tab washer	1 each
12	Generator adapter retaining studs	Nut lock, plain nut, washer	2 each
13	Starter adapter retaining studs	Nut lock, plain nut, washer	2 each
14	Lower tachometer drive cover studs	Nut lock, plain nut, washer	4 each
15	Oil filler spout retaining studs	Nut lock, plain nut, washer	2 each
16	Case front half bottom boss	Hose nipple (one inch across hex flats)	1 each

Figure 4-1 Rear Views of Accessory Case and Appendage Attaching Parts

4–19. INDUCTION SYSTEM. Remove the four nut locks, plain nuts, and washers which attach the carburetor to the manifold studs. Lift the carburetor off the studs, and drain any fuel remaining in it by removing the lower 1/8-inch pipe plug in the regulator cover. Replace the plug. Remove the right rear manifold attaching bolt. Remove two hex head screws, lockwashers, and plain washers which attach each intake tube flange to cylinder ports. Remove lockwire and two bolts which attach the intake and oil drain manifold front boss (and its cover plate, if any). Free the intake tubes from cylinder ports; then lift the assembly of manifold and tubes from the engine, and lay it aside. Remove four nut locks from the fuel pump attaching studs. Loosen and remove the four plain hex nuts, and remove their plain washers. Withdraw the fuel pump assembly to the rear.

4–20. ACCESSORY CASE REAR HALF. (See figure 4–1.) This process can best be carried out with the engine upright. Refer to the illustration for sizes, types, locations and functions of attaching parts called out by index number in the following steps:

a. Loosen the hose elbow to facilitate disassembly of the oil pump. Remove the lock wire from the oil screen plug and cap. Loosen the hex head plug, the oil screen cap, the inlet hose adapter, the oil pressure relief valve cap and its lock nut with suitable open end wrenches. Remove the attaching parts from studs (1) and withdraw the oil pump assembly.

b. Remove attaching parts from studs (2) and withdraw magneto adapters and magneto cluster gears rearward, holding gears in adapters.

c. Remove attaching parts, cover, and gasket from studs (3) on front side.

d. Remove attaching parts, cover, and gasket from studs (4).

e. Remove attaching parts, cover, and gasket from studs (5) unless a vacuum pump was removed from this location, as described in paragraph 4–15.

f. Remove accessory case rear half attaching parts from studs (6) at rear side of case and from studs (7) at front side. Remove accessory case attaching parts from crankcase studs (8) to free the rear half.

g. Hold the upper hydraulic pump gear or plug in the front half and the propeller governor drive gear or plug, the upper tachometer drive gear, the lower hydraulic drive gear, the fuel pump drive gear and the oil pump drive gear in the rear half bushings, then pull the accessory case rear half to the rear until it is free of the studs. See that the fuel pump idler gear remains in the rear half bushing and that the other gears remain in their rear bushings. Pull the parting flange gasket free, and discard it.

h. Turn the rear half of the case, open side upward, and lay it and the gears aside for later disassembly.

i. Remove the upper hydraulic pump drive gear or aluminum plug or steel sleeve plug from the upper left corner bushing in the case front half.

j. Remove the cotter pin, castle nut, and washer which retain the starter jaw, and withdraw it rearward from the pinion splines.

4–21. CYLINDERS, PUSHRODS AND HOUSINGS. These parts may be removed with the engine inverted or in the upright position on the overhaul stand. First, remove attaching screws from all rocker covers; tap the covers to loosen, and remove them to drain oil from the rocker boxes. Then remove all cotter pins from through bolt slotted nuts, if the engine is so equipped, or remove nut locks if plain nuts and undrilled bolts are installed. Use either the Group 4 cylinder base nut wrench, or a standard pattern box end wrench to loosen cylinder base nuts. Turn the crankshaft to place the piston of one of the front cylinders at top dead center, with both valves closed. Remove the base nuts below the cylinder barrel, then remove the four nuts above the barrel, and withdraw the cylinder assembly straight outward, taking with it the pushrods and housings. Catch the piston and lower it carefully until the connecting rod rests on the crankcase chamfer. Remove the pushrods from the cylinder. Pull pushrod housings from the rocker box lower flange. Remove retainers from housing. Remove and discard housing oil seal rings. Remove and save cylinder base packings for other disassembly. All cylinders are removed in the same manner.

4–22. PISTONS. Immediately after removing each cylinder, and before proceeding to the next, remove the exposed piston by pushing its pin endwise to clear the connecting rod bushing. Do not allow original, loose type pin end plugs to fall on concrete.

4–23. TIMING GEARS.

a. Remove lock wire and six hex head screws which retain the crankshaft pinion gear, and pull the gear rearward from the crankshaft.

b. Remove lock wire and four hex head screws which retain the camshaft gear, and pull the gear from the camshaft.

4–24. ACCESSORY CASE FRONT HALF. (See figure 4–1.) Remove accessory case front half attaching parts from crankcase studs (9) and from crankcase Helicoil threads (10 and 11), and withdraw the casting from the long crankcase studs. (Tap lightly, if necessary, to loosen the gasket.)

4–25. CRANKCASE, CRANKSHAFT AND CAMSHAFT. Turn the engine stand to place the 1, 3, 5 side of the

crankcase on top. Place a support under the center of the 2, 4, 6 side of the case. If the pivot is difficult to withdraw it may be driven to the rear with a brass drift from the front end of its pilot hole inside the case. Remove the bolts which attach the 1, 3, 5 side mount brackets to the stand. Remove nut locks and plain nuts from the two short front through bolts, and remove the bolts from the case. Remove nut locks, plain nuts and washers from the two long hex head bolts through the rear mount brackets and crankcase and from the shorter through bolt between them. Withdraw the long bolts. If desired, and provided the shorter through bolt was installed from the 1, 3, 5 side, the right rear mount bracket may be removed by removing two stud nuts, in order to withdraw the remaining through bolt. However, this is not necessary if care is taken to separate the castings without binding the bolt. Remove all crankcase flange bolts and nuts. If nuts are installed on any of the through bolts at cylinder pads they must be removed. Tap the eight long through bolts out of their holes in cylinder pads. Lift the 1, 3, 5 side casting and insert a 3/4-inch wood block between upper parting flanges of the castings and another between lower flanges. Lay cloth pads between the castings to break the fall of connecting rods when the 1, 3, 5 side casting is removed. Slip a used cylinder base packing ring over each pair of valve lifters in the 1, 3, 5 side, so that it will contact the two lifter shanks, and stretch the rubber ring through the cylinder opening and around the pushrod housing flange. Push all lifters away from the camshaft. The rubber ring will retain the upper lifters when the upper casting is removed. Lift the 1, 3, 5 side casting, as shown in figure 4–2, and store it on the parts rack with parting flange upward. The 2, 4, 6 side casting should be removed from the stand and stored in a similar manner after removal of the crankshaft and camshaft.

4–26. CRANKSHAFT AND CAMSHAFT. These parts may be removed by lifting from the crankcase 2, 4, 6 side. Two men should handle the crankshaft and connecting rod assembly, taking care to avoid striking the case with any connecting rod.

4–27. DISASSEMBLY OF SUBASSEMBLIES.

4–28. CRANKCASE

a. Remove hydraulic valve lifters, and store in a suitable rack.

b. Remove three nut locks, plain nuts, and washers to free each pushrod housing flange. Tap with a non-marring hammer to loosen gaskets. Remove all flanges.

c. Remove nut locks, plain nuts, and washers from engine mount bracket attaching studs, and take off the four brackets.

d. Rotate and lift out all main bearing inserts. Discard the intermediate and rear inserts, and store the front main thrust bearing inserts.

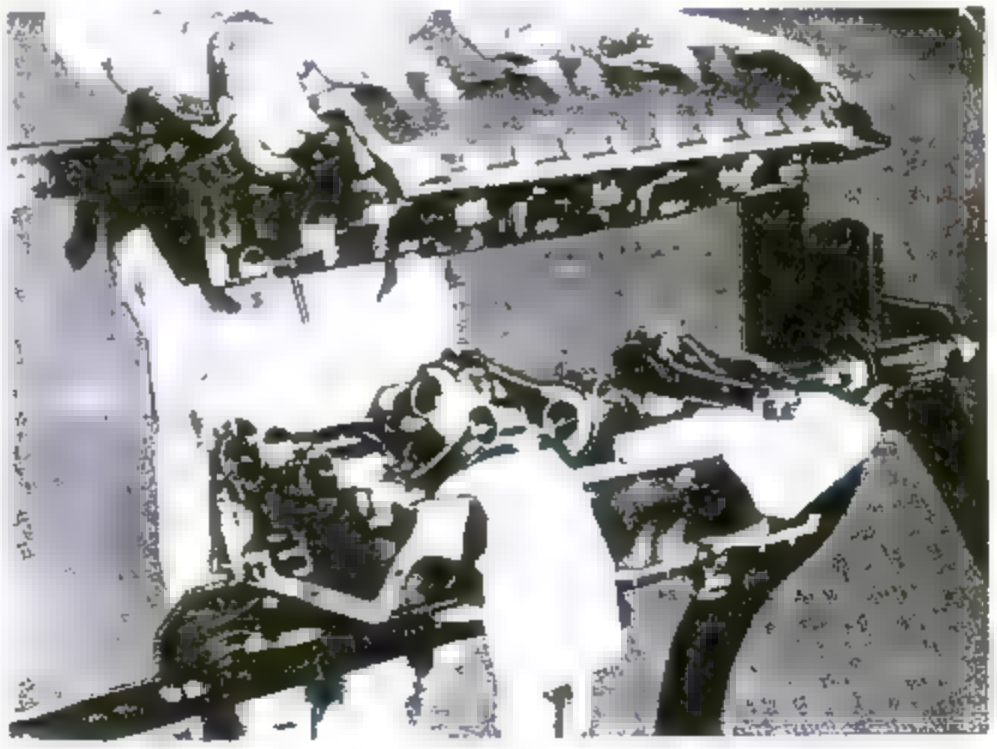


Figure 4–2. Removing Crankcase 1, 3, 5, Side

e. Unscrew the breather hose elbow and the oil hose flared tube elbow from the 1, 3, 5 side casting.

f. Remove all pipe plugs from both castings. Remove the hex head plug from the 2, 4, 6 side oil gallery (front) and the hose adapter from the 1, 3, 5 side oil gallery.

4–29. CRANKSHAFT AND CONNECTING RODS. Two clamp type stands may be used to support the front and rear journals. Do not support flanged shafts on the starter jaw mounting stud. Clamp the crankshaft in the holder to prevent rotation. Use a wrench of standard pattern to loosen the connecting rod bearing cap bolt nuts. Remove cotter pins and nuts from each rod bolt with the crankpin turned to a convenient working position. Separate the rod and cap, and push out the crankpin bearing inserts. Reassemble the rod and cap for storage, with cylinder numbers on the bolt bosses together. Discard bearing inserts. Use Truarc snap ring pliers of the proper size to compress and remove the counterweight pin retaining plate snap rings. Remove the four plates from the counterweight pin holes, and push out the pins.

CAUTION

The counterweights must be tagged to identify the side and direction of original installation on the crankshaft cheek extensions. If they are interchanged or reversed, the reassembled shaft will be out of balance.

Remove the Hubbard plug from the front end hub bore of crankshaft (to permit magnetic inspection) by drilling and tapping a hole exactly in the center of the plug and by pulling it with a slide hammer or other puller. Discard the Hubbard plug. To remove the oil seal, lift out its spring with a wire hook and unhook ends. Twist and slide off rubber and felt ring. Discard seal, but save spring, if undamaged. Do not remove large starter jaw stud from rear end or propeller bolt bushings from flange.

4–30. ACCESSORY CASE HALVES. (See figure 4–1.)

a. Remove attaching parts from the front half studs (12) and withdraw the generator drive.

b. Lift out the upper tachometer drive gear, the propeller governor drive gear or aluminum plug, the lower hydraulic pump drive gear, the oil pump drive gear, and the fuel pump drive and idler gears from their bushings in the accessory case rear half.

c. Remove attaching parts from rear half studs (13) and withdraw the starter adapter.

d. Remove attaching parts, cover, and gasket from rear half studs (14).

e. Remove attaching parts, oil filler spout assembly, and gasket from rear half studs (15).

f. Loosen the hose nipple at the bottom of the front half bottom boss (16) with a suitable open end or deep socket wrench and unscrew it.

g. Loosen all pipe plugs in both castings with Allen wrenches and open end wrenches of proper sizes, and unscrew them.

h. Use Truarc snap ring pliers to spread the lower tachometer drive bushing plug retaining ring only enough to clear the plug end, then lift off the ring, and push the plug from the bushing.

i. Use suitable expansion pullers to remove all accessory drive shaft oil seals in both case halves and the generator adapter.

j. Use Truarc snap ring pliers of proper size and type to spread the generator drive gear retaining ring only enough to clear the shaft, and lift it out. Pull the gear from its adapter bushing, and store the snap ring and aluminum washer in a safe place.

4–31. OIL PUMP. Lift the pump gears carefully from their chambers. Unscrew the hex head plug from the oil screen cap and the cap from the pump body. Remove the oil screen and cap assembly carefully from its chamber. Unscrew the hose elbow, the inlet hose adapter, and the relief valve cap. Back out the relief valve screw, and remove the inner and outer springs. Turn the pump body up so that the plunger and valve sleeve will drop into the palm of the hand.

4–32. INTAKE AND OIL DRAIN MANIFOLD AND INTAKE TUBES. These parts may be separated by loosening the attaching hose clamps and pulling the tubes away. Retain serviceable hose clamps and discard hose connectors. Remove the manifold pressure gage line fitting or 1/8-inch pipe plug installed in the tapped hole at the upper right front corner of the manifold and the 1/8-inch primer hole plug, if installed, from the hole near the carburetor mount pad. Discard intake tube seal rings, and remove flanges.

4–33. CYLINDER ASSEMBLIES. In the following instructions, it will be assumed that a suitable valve spring compressor has been constructed or procured for the work described. Such a tool may be constructed from available steel bar stock, formed and assembled to dimensions shown in figure 4–3. Disassemble each cylinder in the following manner:

a. Place the valve holder in the base recess of the Group 4 cylinder and valve holding fixture. Lower the cylinder over the top of the valve holder and seat its base flange on the fixture. Turn and tighten the fixture clamps to hold the cylinder flange.

b. Push the rocker shaft endwise, and remove the rocker arms. Return the shaft to its normal position in the support bosses.

c. Hook the valve spring compressor under the rocker shaft, so as to bear on one of the outer valve spring retainers, and apply downward pressure to compress the valve springs until the valve stem keys can be removed. Do not allow the retainer to move upward until the keys are out. Binding of the keys between the retainer cone seat and the valve stem in incorrect positions may cause the stems to be nicked.

CAUTION

Do not allow the spring compressor to cock the outer spring retainer so as to touch and score the valve stem.

d. Release pressure, and remove the compressor. Lift off the outer spring retainer, the two springs, and the inner retainer. If an aluminum spacer is installed under the inner retainer, remove it.

e. Disassemble parts from the other valve in the same manner.

f. Lift the cylinder by the valve stems. Lay it on its side, and withdraw the valves through the open end of the cylinder.

CAUTION

Before removing valves, inspect the upper ends of their stems for nicks, whose upstanding edges may score the valve guides if forced through. Remove any such raised material by hand stoning.

4–34. PISTON ASSEMBLIES. Remove piston rings by spreading with the fingers, so that the ring ends will not score the piston lands, and lift off the piston top. Start with the top ring and progress downward. If rings are not free in the grooves, care must be taken to avoid damage. It may be necessary to soak the assembly, less piston pin, in carbon solvent, Specification MIL-C-25107, to free the rings. If rings are completely "frozen" in the grooves, or if the piston is

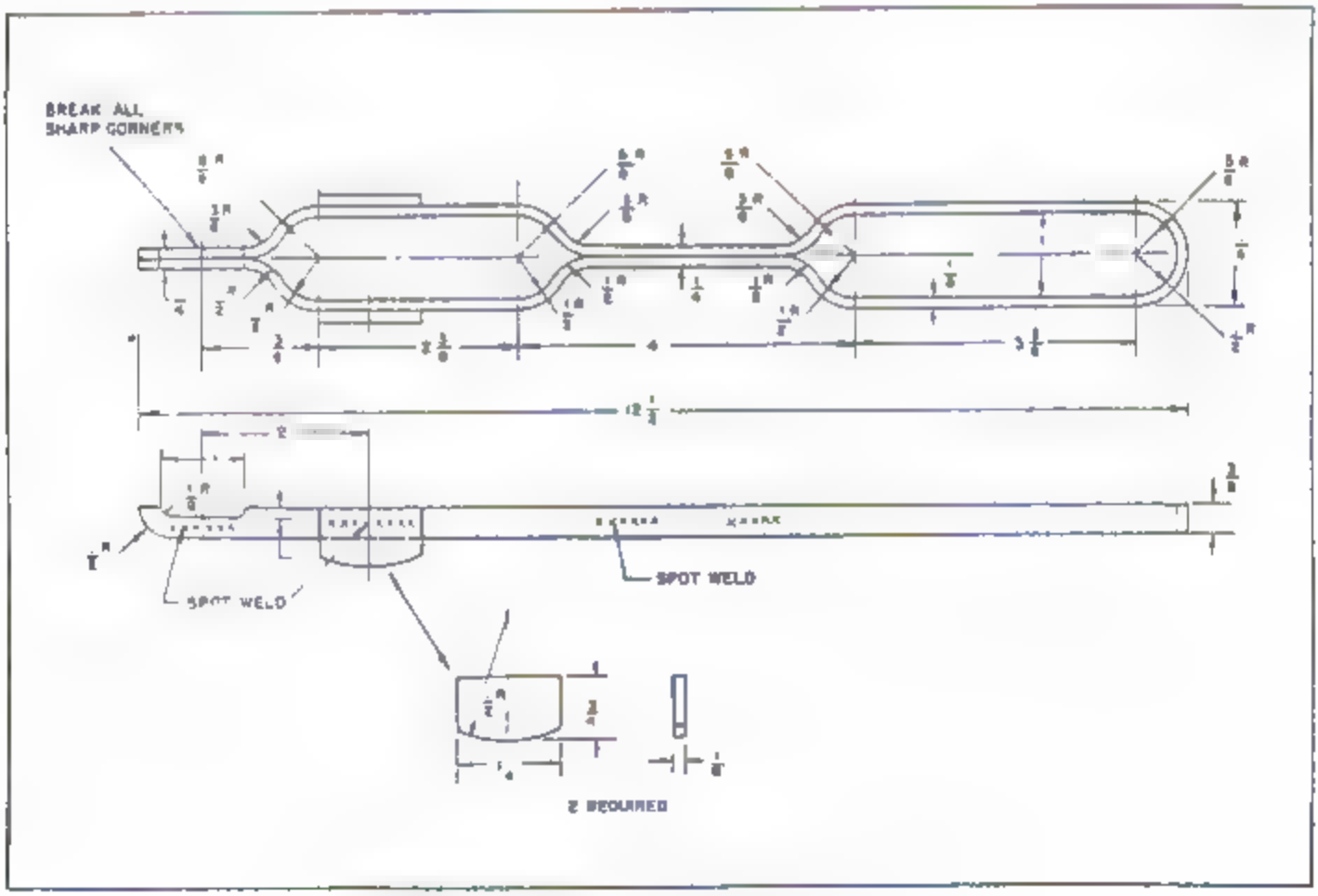


Figure 4–3. Valve Spring Compressor

Figure 4–4. Releasing Hydraulic Unit Check Valve

scored beyond usefulness, push out the pin and plug assembly, and discard the piston.

Note

Some piston pins have end plugs pressed in. The current production type has a single plug which projects from both ends and is forged in place. Do not attempt to remove these plugs.

4–35. IGNITION SYSTEM. To separate the ignition harness from each magneto, remove the four fillister head screws and lock washers which secure the cable outlet plate and withdraw carefully the plate and the attached rubber grommet. Replace the screws and lock washers on the magneto. Further disassembly of the magnetos should be attempted only by personnel trained in magneto repair operations and equipped with the necessary special tools. To remove the magneto terminal parts, unscrew the six cable piercing screws and the cable coupling (flat sided) nuts. Remove the grommet and the plate. Cut the cables to remove the coupling nuts. To remove spark plug contact sleeves and elbows, straighten the wire ends at the sleeve eyelets and pull off the sleeves. Unscrew the knurled coupling nuts, and pull off the elbows. Slide off the lead cones and the knurled nuts. Discard all insulated cables. Store magneto terminal parts with the magnetos in a safe container. Ignition cable conduit assemblies, spark plug terminal parts, magneto terminal parts, and conduit brackets should be separated and retained.

4–36. HYDRAULIC VALVE LIFTERS. When the lifters are disassembled, it is essential that a suitable rack be available for storage of the parts in their original relations. This is an absolute necessity with regard to parts of hydraulic units. It is advisable to disassemble these units immediately before they are to be cleaned and to carry out the disassembly, cleaning, inspection, and reassembly operations in one continuous process. Use the following disassembly procedure:

a. With a knife point or other sharp instrument, carefully pry the wire snap ring from the groove at the outer end of the shank. In order to do this, it will be necessary to depress the socket slightly. Use a discarded pushrod or other ball end tool for this purpose.

Figure 4–5. Removing Plunger From Hydraulic Unit

b. Invert the lifter, and the socket and hydraulic unit will fall into the palm of the hand. Place the body and socket in the rack

c. Usually the hydraulic unit plunger may be removed from the cylinder by pulling it outward, while turning in the direction which tends to "wind up" the spring under its head. If the plunger appears to be "frozen" in the cylinder, it may be held tightly between the oil under it and a ring of carbon on the cylinder wall. To test for this condition and to release the plunger simultaneously, insert a medical swab stick, or similar hard wood dowel, into the open end of the inlet tube, and depress the ball check valve. (See figure 4–4.) This will release oil from the cylinder, and the plunger may be depressed, unless it is actually stuck to the cylinder. A ring of carbon may be disintegrated and the plunger may be removed by both turning and pulling outward, in an oscillating fashion, while gripping the plunger head with tape-covered pliers. (See figure 4–5.)

d. Place the unit cylinder and the permanent plunger and spring assembly in the rack with the mating body and socket.

SECTION V

INSPECTION, REPAIR, AND REPLACEMENT

5–1. DEFINITIONS.

5–2. Terms used in this section to describe various types of defects are described as follows:

a. Abrasion: Scratching of a surface, either by contact with another part or by mechanical cleaning or resurfacing with abrasive materials.

b. Burrs: Sharp, rough, upstanding edges.

c. Corrosion: Deterioration of a surface. This term usually refers to fretting or oxidation of a metal.

d. Deformation: Any departure from correct shape or surface finish, such as bends, bulges, twists, elongation, crushing, flattening, peening, indentation, and gouging.

e. Elongation: Stretching or increase in length.

f. Fretting: Deterioration of a metal surface caused by vibration or chattering of or against another part.

g. Galling: Excessive friction between two metals resulting in particles of the softer metal being torn away and "welded" to the harder.

h. Pitting (or spalling): Small, deep cavities in a metal surface.

i. Oxidation: Chemical combining of a metal, usually steel or iron, with atmospheric oxygen. Surface oxide films formed on aluminum alloy parts serve to prevent further oxidation and are not harmful. Iron oxides do not form a protective film and allow oxidation to continue in the underlying metal, roughening the surface and progressing inward.

j. Scoring: Deep grooves or scratches in the surface of a part caused by abrasion, resulting in increased friction and temperature in the absence of adequate lubrication.

k. Run out: Eccentricity or wobble, expressed in decimal parts of an inch, as indicated by the full deflection of an indicator needle.

5–3. GENERAL INSPECTION PROCEDURES.

5–4. VISUAL INSPECTION. All parts should be examined for visible defects, such as cracks, deformation, elongation and corrosion, which would render them unserviceable, before they are subjected to dimensional and other time consuming inspections. A magnifying glass may be employed to advantage for examination of suspected cracks. Parts should be checked for cleanliness of all surfaces, including cavities and oil passages and for complete removal of residues of cleaning materials. Critical machined surfaces should be examined for nicks, deep scratches, galling, burning, and excessive scoring. Threads should be examined for deformation, such as nicks, pulling, cracking, crossed threads, peening, and stripping.

5–5. ETCHING. Any aluminum alloy parts suspected of cracks should be surface etched in the area in question. The following instructions shall be followed carefully, both as to duration of chemical action and as to strength of the solution.

a. The surface must be free of carbon, varnish, and enamel. Avoid removal of metal by scratching to prevent false indications.

b. Immerse the part, if small, or paint the area with a solution of two pounds of caustic soda in one gallon of water at room temperature. Do not expose the surface to this solution longer than 60 seconds.

c. Immediately rinse the part in running water.

d. Neutralize the alkali with a solution of 25 percent nitric acid (one part acid in three parts water, heated to 38°C (100°F). Allow the acid to remain in contact with the surface long enough to dissolve the black deposit.

e. Rinse in running water, and dry the part with a blast of dry compressed air.

f. This etching process will leave a black deposit in any crack, while the surrounding surface will be thoroughly clean. Fine cracks may be located with the aid of a magnifying glass.

5–6. MAGNETIC INSPECTION. Stressed steel parts listed in Table IV shall be inspected by the Magnaflux processes indicated. All parts must be clean and free of carbon and oil varnish deposits and oil before inspection. The crankshaft and piston pins must be polished smooth before being magnetized. In the wet continuous process, Red Magnaflux Paste No. 9 is used in a mineral spirit vehicle. The suspension is maintained at a ratio of 1 to 1-1/2 ounces of paste to 1 gallon of liquid. Springs will not be inspected by this process.

TABLE IV. MAGNETIC INSPECTION DATA

PART NAME	METHOD OF MAGNETIZATION	AMPERES	METHOD OF INSPECTION	POSSIBLE DEFECTS AND CRITICAL AREAS
CRANKSHAFT	Circular	2500	Wet Continuous	All Journals – Fatigue cracks. Fillets and oil holes, No. 1 main journal and No. 1 and 2 crankpins – Fatigue cracks. Thrust flanges at front journal – Heat cracks. (See note in paragraph 5–6.)
CONNECTING ROD	Circular	1800	Wet Continuous	All areas – Fatigue cracks, opened inclusions.
CAMSHAFT (FORGED)	Circular	1500	Wet Continuous	All areas – Fatigue cracks.
PISTON PIN	Circular	1800	Wet Residual	Shear planes, ends – Fatigue cracks. All areas – Stringers.
ROCKER ARMS	Circular	1800	Wet Continuous	Valve contact face – Fatigue cracks. (Intake rocker only – squirt nozzle).
CAMSHAFT GEAR	Circular	1800	Wet Continuous	Teeth – Fatigue cracks. Square hole – Fatigue cracks.
ACCESSORY DRIVE GEAR	Circular	1800	Wet Continuous	Teeth – Fatigue cracks. Eccentric – Heat cracks. Screw holes – Fatigue cracks.

Note

All parts shall be checked carefully for other indications such as grinding cracks, forging laps, and seams. If any crankshaft defect is suspected, demagnetize the crankshaft and magnetize longitudinally for further inspection.

5–7. SPECIFIC INSPECTIONS.

5–8. CRANKCASE. In addition to inspection for the usual visible defects, such as cracks, stripped or deformed threads, nicks and peening, the following points shall be inspected in detail:

a. Camshaft bearings: Look for heavy scoring and imbedded particles. Inspect for wear with Group 2 cam bearing gage

b. Main bearing seats: Look for wear in notches and tang stops.

c. Oil galleries and drilled passages: Check cleanliness

d. Valve lifter guides: Look for scoring. Check for uniformity of oil feed hole end positions. Inspect for wear with the Group 6 valve lifter bearing gage.

e. Front main-thrust bearing boss: Check alignment of machined ends of bearing seat.

f. Cylinder pad studs: Inspect for cracks, bending, elongation, and thread condition.

g. Through bolts: Inspect for cracks and thread condition.

h. Magneto drive gear supports: Inspect bearing surface for size.

i. Starter pinion pivot: Inspect pinion bearing surface for wear.

5–9. PARTS NOT TO BE RE-INSTALLED.

5–10. The following parts are not subject to repair. All parts in these categories shall be replaced with new parts at each overhaul: Pushrod housing packing, rubber hoses, "O" ring hydraulic gaskets and packings, cylinder base packings, garlock type oil seals, gaskets (soft composition), gaskets (copper-asbestos), tab washers, lock washers, nut locks, self locking nuts, cotter pins, and piston rings.

5–11. STUD REPLACEMENT.

5–12. AVAILABLE OVERSIZES. Studs supplied by the engine manufacturer under his part numbers are available in oversizes listed in the second column of Table V. Part numbers and identification are indicated

TABLE V STANDARD AND OVERSIZE STUD IDENTIFICATION

Typical Part No.	Oversize on Pitch Dia of Coarse Thread (inches)	Optional Identification Marks on Coarse Thread End		Identification Color Code
		Stamped	Machined	
XXXXXX	Standard	None		None
XXXXXXP003	0.003			Red
XXXXXXP006	0.006			Blue
XXXXXXP009	0.009			Green
XXXXXXP007	0.007			Blue
XXXXXXP012	0.012			Green

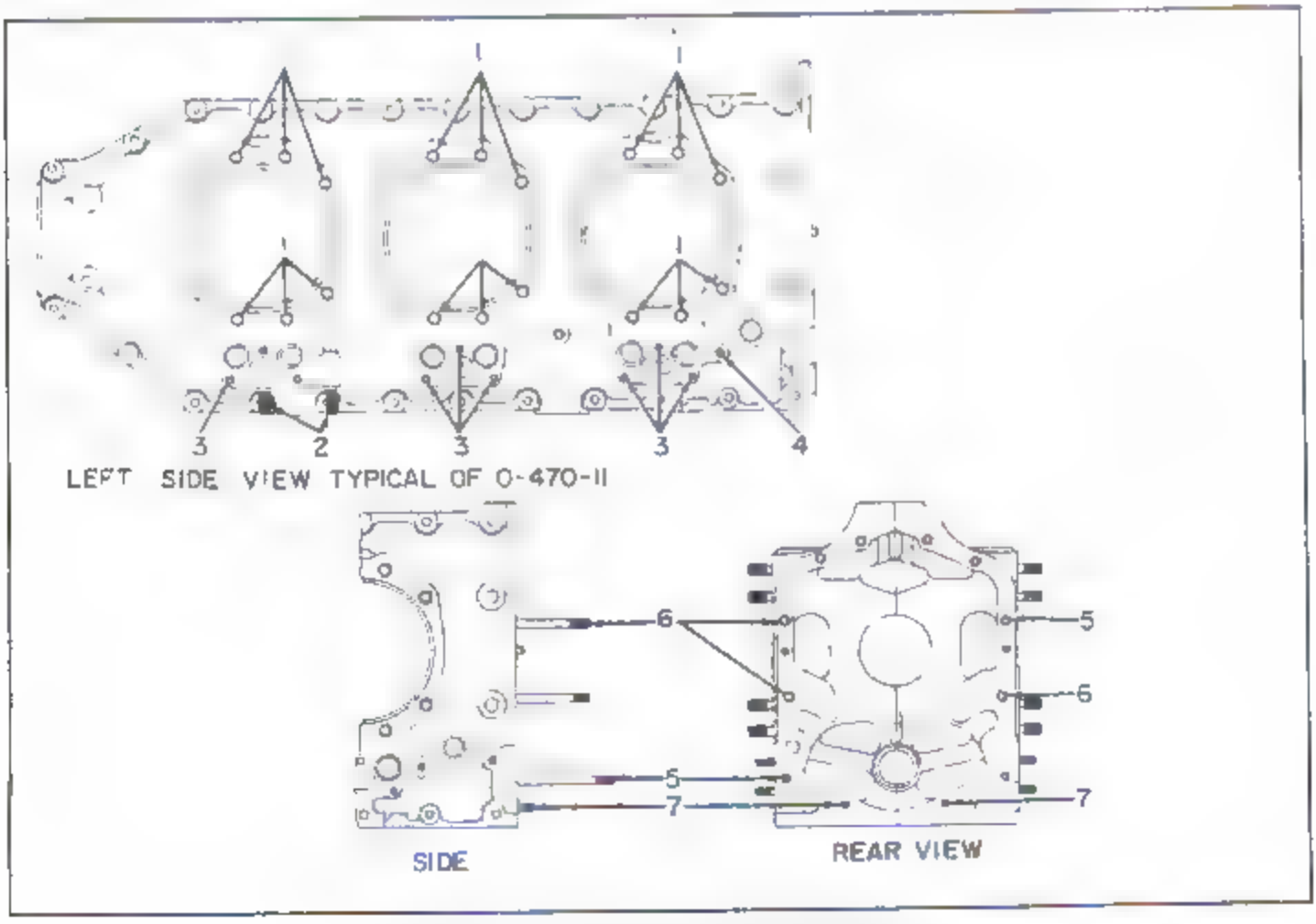


Figure 5–1. Crankcase Stud Setting Heights

in the remaining columns. Available oversizes of AN stud bolts and their part numbers may be found on the AN standard part drawing for the range of numbers which includes the standard size bolt stud part number.

5-13. REMOVAL OF STUDS. Stripped, crossed, and bent studs may be removed with any standard type of stud remover. Studs which are broken off at or near the surface must be removed by drilling a hole in the center of the remaining portion of proper size to fit a spring type remover. The removing tool may be tapped into the hole and the stud backed out by turning the tool to the left.

5-14. RETAPPING. Determine, from the end shape of the stud removed, the next larger oversize. Use the proper tap of the Group 1 oversize tap set, to clean out the casting hole to fit the oversize stud. Exercise care to avoid altering alignment of the hole. The oversize tap should be lubricated with a mixture of one part lard oil, Federal Specification C-O-376, and two parts kerosene, Federal Specification VV-K-211, or a suitable alternate tapping lubricant intended for soft metals.

5-15. STUD INSTALLATION. The stud driver should be a type which will hold and drive the new oversize stud without damage to the fine thread. It should have a stop to correct shape for studs with spherical ends. If the stop is incorrectly formed, or if it is worn, there is danger of damage to the end thread of the stud, making installation of the nut difficult or impossible. Before driving a stud in a blind hole, the hole must be blown out with dry compressed air to remove all loose chips and lubricant. Spread a thin film of anti-seize compound, Specification MIL-T-5544, on the coarse thread. Turn in the stud slowly to avoid heating and tearing the casting metal. The coarse thread of any stud to be installed in an open casting hole should be coated with National Oil Seal or an equivalent non-hardening sealing compound. Drive the stud to a depth which will leave the "setting height", or length of the end projecting from the machined surface, as specified in Tables VI and VII and figures 5-1 and 5-2.

5-16. THREAD CHASING. Standard taps may be used carefully to clean out tapped holes. Threads of studs may be chased with chasing nuts, however, this should be attempted only when the damage is slight. Removal of the cadmium plating of studs allows corrosion.

5-17. STONING.

5-18. Nicks and light scores may be smoothed by the use of an Arkansas hard stone or a fine India stone. A film of oil on the stone prevents loading of the surface and increases the cutting action. When an India stone is employed, care must be exercised to avoid cutting of the finished surface. Stoning should aim only to remove projecting burrs and raised edges

TABLE VI. STUD SETTING HEIGHTS

FIGURE NO	INDEX NO.	LOCATION	THREAD SIZE	TOTAL QUANTITY	SETTING HEIGHT (INCHES)
		CRANKCASE			
5-1	1	Cylinder pads	7-16-14x7/16-20	36	0.87
5-1	2	Front mount bracket pads (2)	3/8-16x3/8-24	8	1.00
5-1	3	Pushrod housing flanges (6)	1/4-20x1/4-28	18	0.69
5-1	4	Rear mount bracket pads (2)	5/16-18x5/16-24	4	0.91
5-1	5	Rear parting flange	5/16-18x5/16-24	2	3.62
5-1	6	Rear parting flange	5/16-18x5/16-24	3	2.69
5-1	7	Rear parting flange	1/4-20x1/4-28	2	0.56
		CYLINDER HEAD			
		Exhaust pipe flange	5/16-18x5/16-24	12	0.78
		INTAKE AND OIL DRAIN MANIFOLD			
		Carburetor	5/16-18x5/16-24	4	0.87
		REAR MOUNT BRACKETS			
		Oil sump support	5/16-18x5/16-24	2	0.56

TABLE VII. ACCESSORY CASE STUD SETTING HEIGHTS

FIGURE NO	INDEX NO	LOCATION	THREAD SIZE	TOTAL QUANTITY	SETTING HEIGHT (INCHES)
		ACCESSORY CASE REAR HALF			
5–2	1	Propeller governor pad	5/16-18x5/16-24	4	1.22
5–2	2	Tachometer drive pads	1/4-20x1/4-28	4	0.75
5–2	3	Magneto adapter pad	1/4-20x1/4-28	4	0.47
5–2	4	Magneto adapter pad	5/16-18x5/16-24	4	2.57
5–2	5	Front parting flange	5/16-18x5/16-24	2	1.22
5–2	6	Starter adapter pad	1/4-20x1/4-28	2	0.75
5–2	7	Starter adapter pad	3/8-16x3/8-24	6	2.55
5–2	8	Lower hydraulic pump pad	1/4-20x1/4-28	4	0.88
5–2	9	Oil pump pad	5/16-18x5/16-24	6	0.94
5–2	10	Fuel pump pad	5/16-18x5/16-24	4	0.906
5–2	11	Oil filler spout pad	1/4-20x1/4-28	2	0.700
		ACCESSORY CASE FRONT HALF			
5–2	12	Upper hydraulic pump pad	5/16-18x5/16-24	4	0.906
5–2	13	Rear parting flange	5/16-18x5/16-24	1	1.81
5–2	14	Rear parting flange	5/16-18x5/16-24	2	2.06
5–2	15	Rear parting flange	5/16-18x5/16-24	*13	1.19
5–2	16	Generator adapter pad	3/8-16x3/8-24	5	2.18
5–2	17	Generator adapter pad	1/4-20x1/4-28	2	0.75
5–2	18	Rear parting flange	5/16-18x5/16-24	**1	2.12

* 14 on Serial No. 100001 through 100845
** Only on Serial No. 100846 and higher

of nicks and scores. A triangular stone may be used to smooth large, external threads.

5–19. WELDING.

5–20. The only part of the engine which may be repaired by welding is the oil sump. If a cracked or otherwise damaged sump is to be welded, all exterior and interior surfaces must be completely free of oil. If the weld is made in the cubical portion or neck of the sump body, care must be taken to avoid burning through the thin metal and welding stresses must be relieved. Brazing may be employed as a means of repairing brackets and clips. After a welded sump is put into service, it must be watched for development of fatigue cracks caused by stresses and embrittlement.

5–21. HELICOIL INSTALLATION.

5–22. Table VIII provides tool and part number information and dimensional specifications necessary for correct installation of Helicoil inserts in stripped or otherwise damaged tapped holes for screws and studs. If the retapped hole is of correct pitch diameter, the thread fit of the installed Helicoil insert with a standard size screw or stud will be within manufacturing limits for the original parts. Proceed in the following steps.

a. Refer to Table VIII for the correct tap drill size. Drill to a depth 0.02–0.06 inch greater than the length of the Helicoil to be installed.

b. Dip the Helicoil roughing tap in a suitable tapping lubricant for soft metals, such as a mixture of

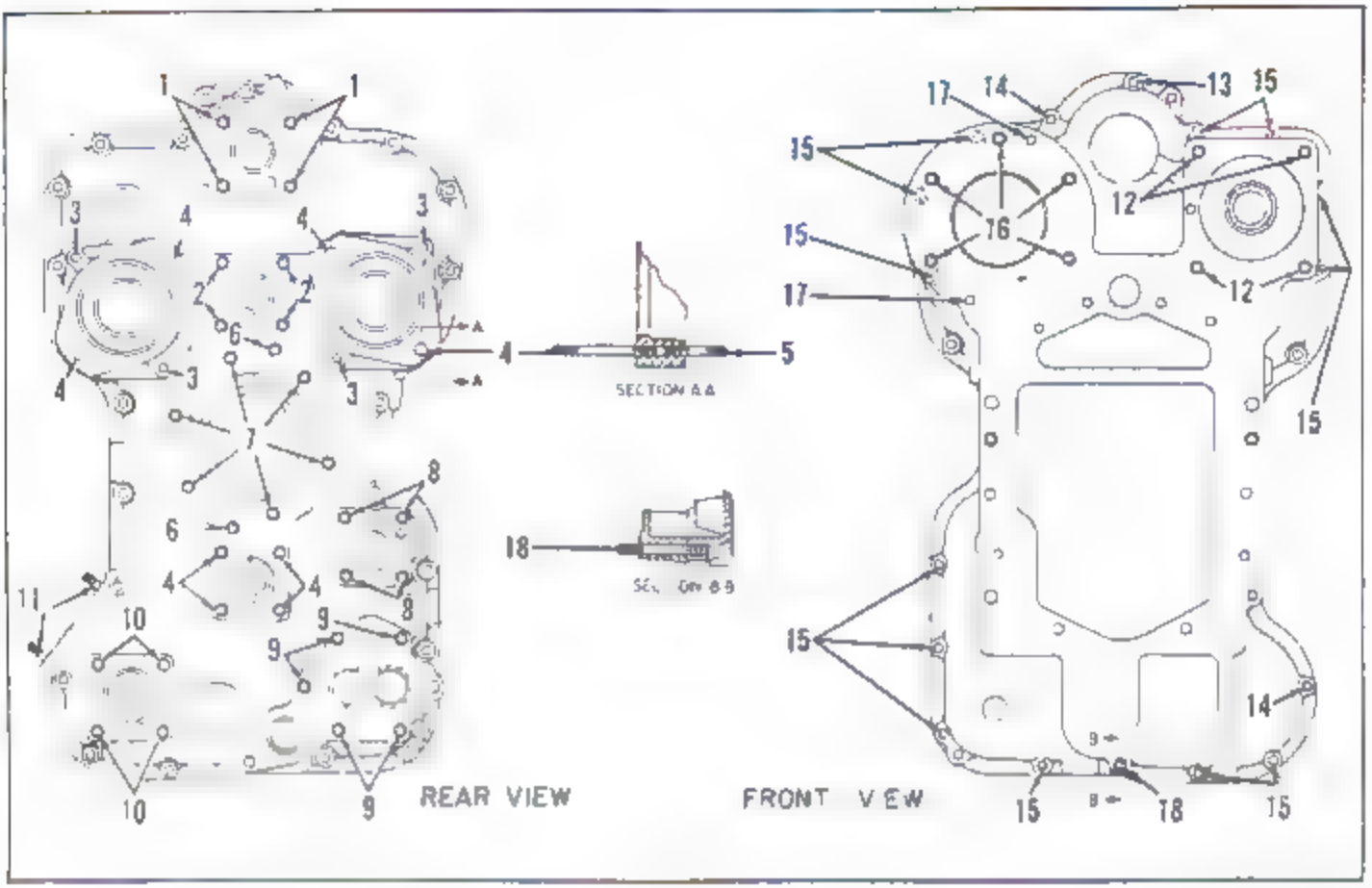


Figure 5–2. Accessory Case Stud Setting Height

TABLE VIII. MANUFACTURER'S NUMBERS OF HELICOILS AND TOOLS

SIZE	INSERTS HELICOIL PART NO	BASIC LENGTHS (INCHES) 1-1/2 DIA	2 DIA	TAPS ROUGHING	TAPS FINISHING	GAGES (THREAD PLUG)	INSERTING TOOLS (PREWINDER TYPE)
10-24	1185-3	9/32	3/8	186-3		188-3	
1/4-20	1185-4	3/8	1/2	186-4		188-4	
5/16-18	1185-5	15/32	5/8	186-5		188-5	
3/8-16	1185-6	9/16	3/4	186-6		188-6	
7/16-14	1185-7	21/32	7/8	186-7		188-7	
1/2-13	1185-8	3/4	1	186-8	187-7	188-8	528-8N
18mm.	C2-52	0.343 (special)		2-22			

Notes 1. Add to Helicoil insert part number: "B" for phosphor bronze, "C" for stainless steel
Example: 1185-5B (5/16 bronze.)

2 Add to Helicoil insert part number: "N" for notched insert (to facilitate breaking off tang)
Example: 1185-5BN.

3. Add to Helicoil insert part number: X (length in inches).
Example: 1185-5BNx15/32 5/16 bronze notched insert 1-1/2 diameter in length.

one part card oil, Federal Specification C-O-376, and two parts kerosene, Federal Specification VV-K-211. Tap to the depth of the drilled hole. Blow out all liquid and chips with compressed air.

c. Repeat step b, using Helicoil finishing tap.

d. Install the correct Helicoil with a Helicoil installing tool of proper size. The outer end must lie in the first full thread.

e. Break off the Helicoil driving end by bending it back and forth with long nose pliers.

CAUTION

Do not install Helicoils in cylinder hold down stud holes. They are not approved for that application.

5–23. CYLINDER ASSEMBLIES.

5–24. INSPECTION. Inspect the following:

a. Fins: Observe any bending of steel barrel fins. Look for cracks and broken sections in head fins. Not more than 10 percent reduction in fin area by breakage or removal of material to stop cracks is permissible.

b. Base flange: Inspect for bending of flange, cracks at stud holes and roughness of nut seats.

c. Cylinder bore: Inspect visually for glaze. Glazed barrels should be roughened by light honing. Use a cylinder dial gage to check bore diameter and reduction of taper (choke).

d. Rocker shaft supports: Inspect the three support bosses of each cylinder for fine radial cracks. Etch any suspected area to define a possible crack. Inspect the ends of the bearing bores for sharp edges. Specify removal of such sharpness.

e. Rocker shaft bearings: Use the "No Go" end of the Group 4 cylinder head rocker shaft bore gage, to inspect for excessive wear in standard bearings. Use the step gage end of the same tool to inspect repair bushings for correct bore diameters.

f. Valve guides: Inspect for heavy scoring. Use Group 6 valve guide stem hole gages to check wear. The two gages are marked "Intake" and "Exhaust." Use each gage in the proper guide. The dimensional difference in diameters is small but important. Each gage has a "No Go" end for worn guides and a "Go" and "No Go" step gage end for replacement guides.

g. Spark plug inserts: Inspect 18 mm. helicoil inserts for correct position and any evidence of loose fit or distortion of ends.

h. Valves: Inspect for warped heads, scoring of stems, nicks in key grooves, excessive groove wear, excessive face, or tip regrind.

i. Valve springs: Inspect for broken ends and rest spring force.

Note

If springs are current types (as indicated by test), see that each has a blue paint stripe.

j. Valve spring retainers: Inspect for cracks and worn seats.

k. Valve rockers. Inspect rockers for excessive wear. Check oil passages for clear channel. Look for excessive bushing wear, using Group 6 rocker arm bushing gages. One of the two gages in the set is for standard size bushings used with standard size rocker shafts. The other is for 0.005-inch oversize reamed bushings to fit 0.005-inch oversize rocker shafts. Each gage has a "No Go" end for worn bushings and a "Go" and "No Go" step gage end for either replace standard bushings or those being reamed to oversize.

l. Rocker cover: Look for broken baffle extensions, cracks and warped mounting surface. Inspect areas at end positions of rocker shaft for cutting done by sharp shaft ends. If the shaft has cut deeply into the cover, its ends will require chamfering.

5–25. CYLINDER BORE. Cylinder walls should be roughened to a profilometer reading of 30 to 40 micro inches R.M.S. if they have become glazed. Extremely smooth walls will not seat new chrome plated top piston rings. The roughening may be accomplished by honing without enlargement of the bore. If the cylinder bore is not in excess of 0.005 inch larger than standard dimensions and if it is not excessively out of round or lacking in choke (taper) it will not require regrinding, and standard size pistons may be installed with either standard or 0.005 inch oversize rings, depending on

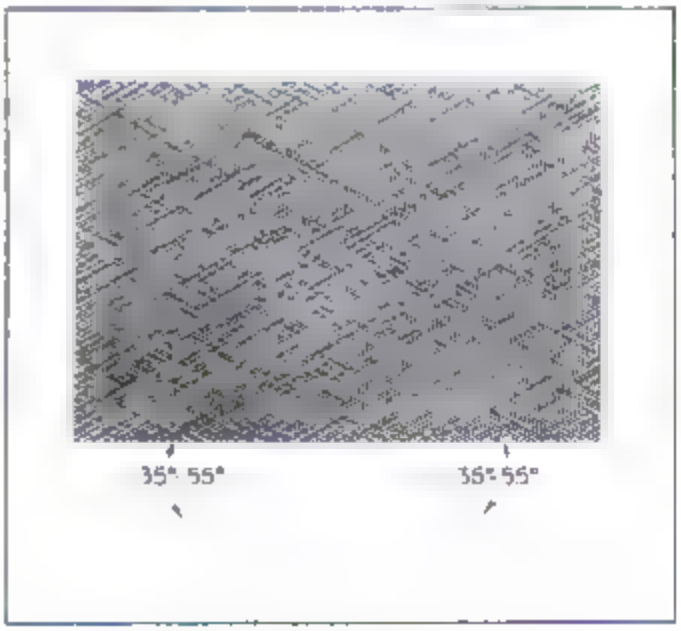


Figure 5–3. Honing Scratch Pattern

exact bore diameter. (Refer to limits No. 1, 2, 3 and 4, Section X.) If the barrel bore cannot be refinished within the limits specified as "Replacement Maximum" the cylinder may be reground to the exact oversize specified in limit No. 5, Section X. The oversize bore dimensions at top and bottom may be determined by adding the amount of oversize to the "New Parts" limits for standard cylinders. The choke (taper) of oversize barrels must remain within the "Replacement Maximum" limit, and the choke specified for new parts is to be preferred, since it will allow longer service. Reground cylinder walls must have a surface roughness of 30 to 40 micro inches R.M.S. This finish should be accomplished by honing with No. 400 grit stones. The stroke must be rapid so as to produce a scratch pattern as illustrated in figure 5–3. A slow longitudinal movement of the hone will result in a circular pattern which is not conductive to development of good bearing or early ring seating and which allows excessive oil consumption. Allowance for honing must be made in the oversize grinding operation. Honing should aim at reduction of roughness and production of the correct scratch pattern, rather than reduction of the basic surface. Honing must not alter the choke produced by grinding.

Note

The cylinder barrel is to be parallel for a distance 3-3/8 inches from the open end (skirt). The taper specified in limit No. 3, Section X, occurs between that level and the top (head) end of the barrel.

5–26. IDENTIFICATION OF OVERSIZE CYLINDERS. Cylinders which have been repaired by grinding to 0.015 inch oversize shall be permanently stamped, on one of the flat sides of the cylinder mounting flange.

5–27. SPARK PLUG HELICOILS.

5–28. INSPECTION. Inspect to see if the original Helicoil has been damaged, without damage to the tapped hole in the cylinder head.

5–29. REPLACEMENT

a. With a sharp pointed instrument, pry the outer end of the Helicoil away from the tapped hole. This end has a series of teeth which are forced into the cylinder head metal when the Helicoil is installed. The teeth must be clear of the hole.

b. Use a Helicoil removing tool to unscrew the original Helicoil. Tap the square, tapered end of the tool into the Helicoil so that it will get a good "bite." Unscrew the Helicoil by turning to the left. (See figure 5–4.)

c. Inspect the tapped hole for thread condition. Slight damage may be repaired by chasing with an 18 mm. Helicoil tap. It is not advisable to repair the assembly if the damage is severe.

d. Use the 18 mm. Helicoil installing tool to install the replacement Helicoil. (See figure 5–5.) Place the Helicoil over the slotted driving end of the rotating stem in the cut out tool body. The toothed end of the Helicoil goes toward the turning handle so that it will enter the hole last. The stem driving slot will engage the bend driving end of the Helicoil. The Helicoil is notched near the bent end to permit easy breaking of the end after installation. Coat the Helicoil surface with anti-seize compound, Specification MIL-T-5544. Turn the handle to wind the Helicoil into the threaded

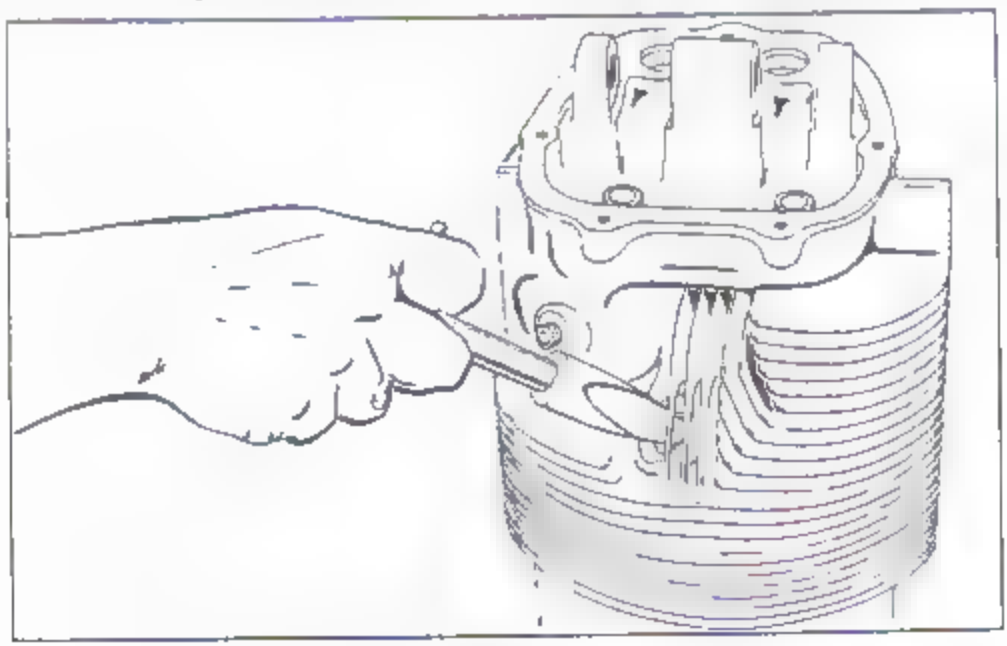


Figure 5–4. Removing Spark Plug Helicoil

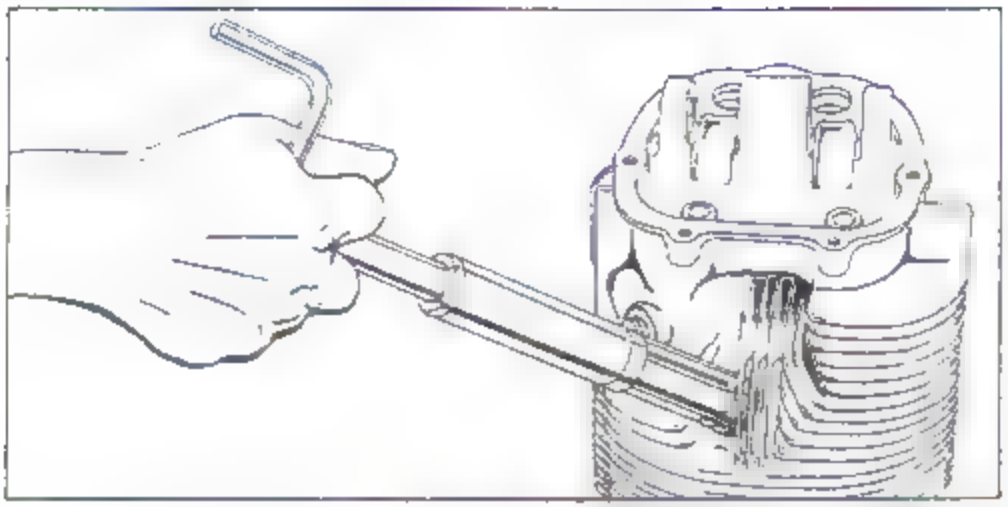


Figure 5–5 Installing Spark Plug Helicoil

Figure 5–6. Expanding Spark Plug Helicoil

end of the tool. This compresses and guides the Helicoil so that it will enter the hole easily.

e. Place the threaded end of the tool against the cylinder head so that the driving stem enters the tapped hole and carefully center the tool on the hole. Turn the handle to wind the Helicoil into the tapped hole until the toothed end, visible through the tool slot, has just entered the last full thread. The teeth must not lie in the imperfect portion of the last thread, nor should the Helicoil be driven so deeply as to emerge in the combustion chamber.

f. To break off the Helicoil driving end, grip the bent end with a pair of long nose pliers, and bend back and forth several times.

g. Attach the expanding and staking tool to a suitable "T" handle drive; coat the tool thread with anti-seize compound, Specification MIL-T-5544, and turn it into the Helicoil. (See figure 5–6.) The tool will expand the Helicoil tightly into the tapped hole, and the final threads of the tool will force the teeth of the Helicoil into the cylinder head metal to prevent accidental removal. Back out the expanding tool, and inspect the new Helicoil. Turn a spark plug into the hole to check for free thread fit.

5–30. INTAKE FLANGE HELICOILS.

5–31. INSPECTION. Inspect the 1/4-20 Helicoils installed in the cylinder head intake flange to see if they are damaged.

5–32. REPLACEMENT

a. Remove the damaged Helicoil with the Helicoil removing tool. Tap the tool square tapered end into the Helicoil to "bite" into the threads. Turn the tool to the left to unscrew and remove the original part.

b. Inspect the tapped hole. Clean it, if necessary, with dry cleaning solvent, Federal Specification P S-661, and blow out all liquid with compressed air.

c. Place a new Helicoil on a 1/4-inch Helicoil installing tool, open end first, and engage the driving rang in the stem slot.

d. Place the driving end of the tool and Helicoil in the tapped cylinder head hole, and turn the Helicoil in until its outer end lies in the last full thread. Withdraw the tool and break off the driving end by bending back and forth with long nose pliers. Make sure that the broken end is removed

5–33. VALVE GUIDE.

5–34. INSPECTION. Inspect for scored and worn guides.

CAUTION

Make sure all carbon has been removed from the inner end of the guide.

5–35. REPLACEMENT.

a. Place the cylinder in the inverted position on the Group 4 cylinder head holding fixture, installed in an arbor press.

b. Insert the Group 6 valve guide remover into the guide stem hole, and bring the ram down on the tool end, making sure that the tool is square with the guide. Apply pressure to force the guide from the cylinder head bore. (See figure 5–7.)

c. Remove the cylinder from the fixture, and inspect the cylinder head guide bore for scoring. If the bore is not damaged it will be possible to make replacement with a standard size guide, provided that the proper tight fit can be obtained. (Refer to limits No. 8 and 9, Section X).

d. If the cylinder head valve guide bore is scored or worn, it will be necessary to refinish by reaming. Use the Group 6 cylinder head valve guide hole reamer, to ream to the first oversize (0.005 in.). Make sure that the reamer is square with the cylinder. The Group 4 cylinder and valve holding fixture may be used to hold the cylinder during this operation.

e. Measure and compare the reamed hole with the outside diameter of the oversize guide inner end. (Refer to limits No. 8 and 9, Section X). Bores reamed to 0.005 inch oversize may be measured with Group 6 cylinder head valve guide bore gage. If a 0.010 inch

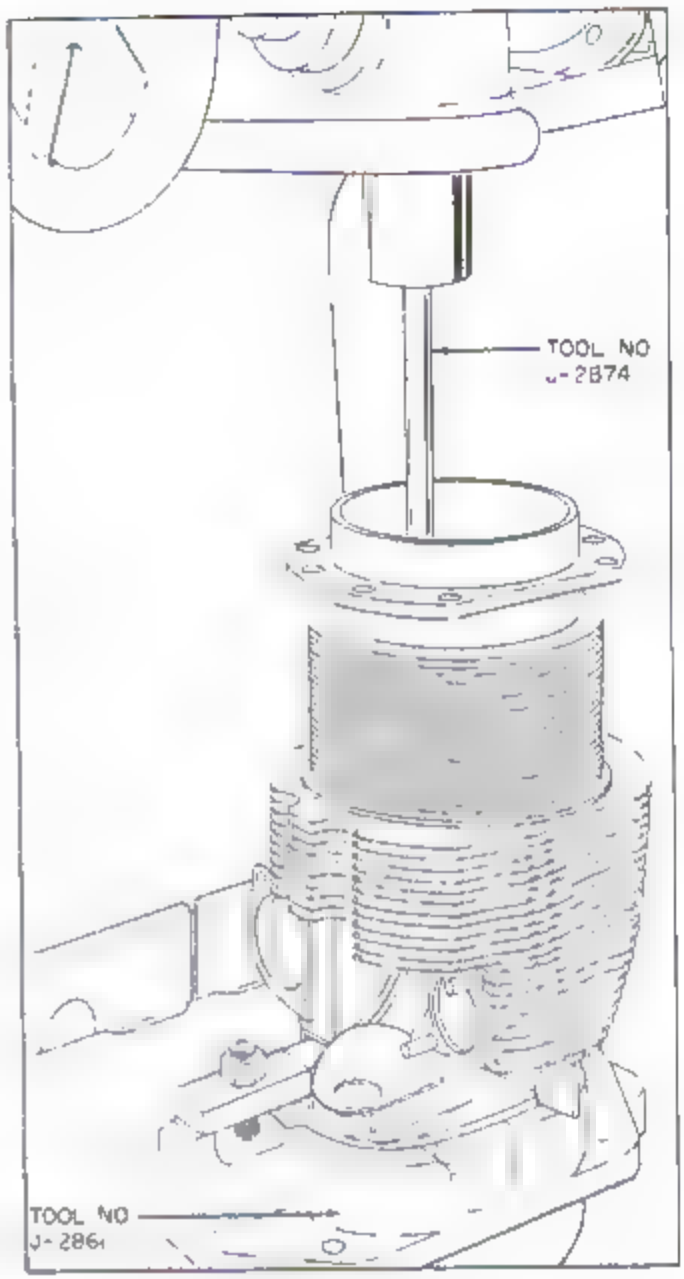


Figure 5–7. Removing Valve Guide

oversize guide is required for second replacement, use Group 6 oversize guide.

f. The end of the oversize or standard replacement guide toward which the flat side of the flange faces will be installed in the cylinder head hole. Dip this end in engine lubricating oil, Specification MIL-L-2104, grade 50.

g. Insert the other end of the guide in the Group 6 valve guide installing driver, and start the lubricated end into the cylinder head bore

h. Bring the arbor press ram down on the driver, and check alignment of the tool with the cylinder. Apply pressure to drive the new guide into place until its flange stops against the cylinder head. (See figure 5–8.)

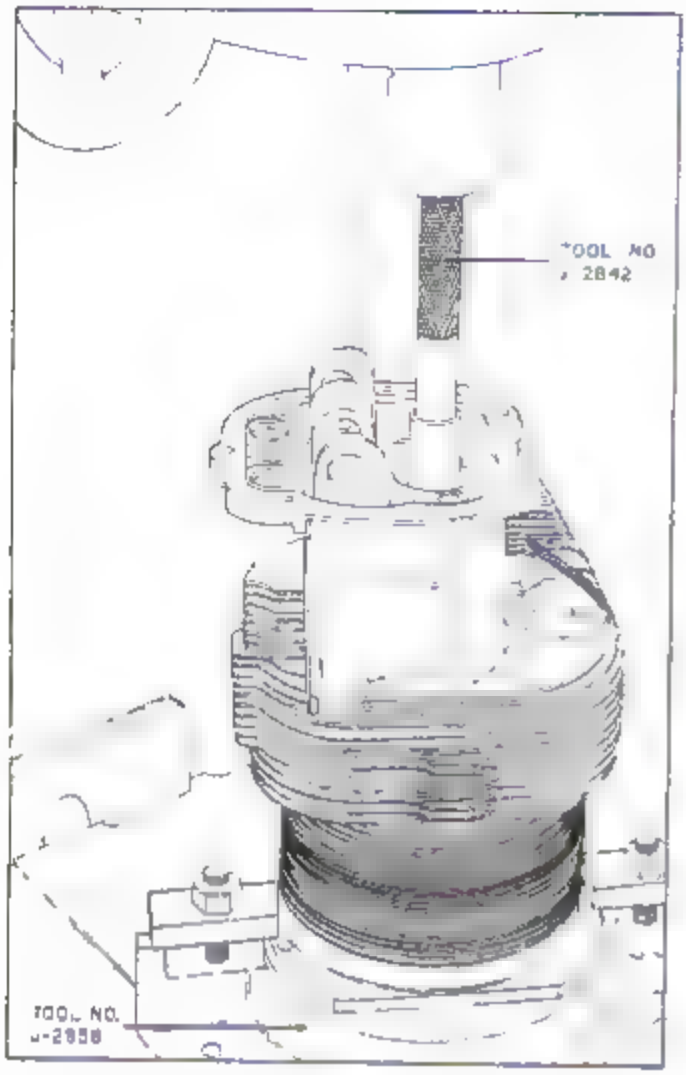


Figure 5–8. Installing Valve Guide

i. Remove the driver, and select the proper Group 6 valve guide stem hole broach. The two broaches in the set are marked for identification. The intake valve guide must be slightly smaller in finish stem hole bore than the exhaust valve guide.

j. Install the entering pilot into the outer end of the new guide so that the first cutter rests on the guide end, and square the broach with the guide. Apply pressure to force the cutters and following burnishers through the guide. Do not allow the broach to drop.

k. Use the Group 6 valve guide stem hole gage to measure the new guide stem hole, selecting the proper gage from the set for the intake or exhaust guide being checked. The "Go" step of the gage should enter the stem hole fully, but the "No Go" step should not enter at all. If the broached hole is within these limits, it will fit the valve stem properly. If the "Go" step does not enter, the broach has worn beyond usefulness and must be replaced.

5–36. VALVE SEAT.

5–37. INSPECTION. If regrinding has increased the width of valve seats beyond the limits specified in the Table of Limits, Section X, they may be replaced with oversize seat inserts, which are available in sizes 0.005, 0.010, 0.015, 0.020, and 0.030 inch larger on the outside diameter than standard inserts. The cylinder head counterbore must be bored out to a size smaller than the insert to be installed by the amount of interference (tight) fit specified in limits No. 6 and 7, Section X. The sizes of counterbore and insert must be measured at room temperature. No special reboring tools are supplied.

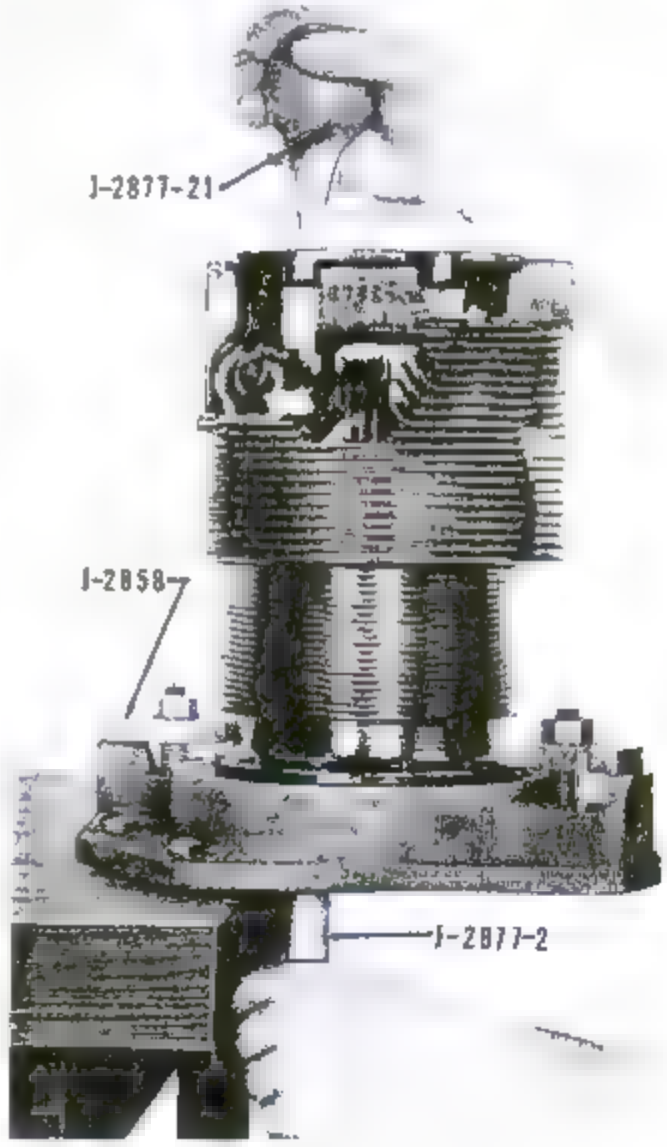


Figure 5–9. Removing Valve Seats

5–38. REPLACEMENT

a. Place the cylinder and head assembly in an oven, and bring the temperature to 301.6°C (575°F). Allow the assembly to remain long enough to become heated throughout. Usually 1/2 to 1 hour is required for heating in a well insulated oven. Do not heat longer than 1 hour.

b. Remove the cylinder from the oven, and place it in the upright position on the Group 4 cylinder and valve holding fixture, with the valve holder removed. The fixture must be so supported that the valve seat removing tool may be inserted through the opening in the base. (See figure 5–9.)

c. Insert the correct Group 6 valve seat remover tool through the open bottom of the fixture and, observing the tool through the valve guide, align the remover pilot with the guide stem hole. Push the pilot through the guide until the magnet draws the tool to the insert.

d. The Group 6 rubber syringe should be filled with cool water while the cylinder is being heated and should be ready for immediate use. Insert the syringe tube into the water hole in the remover pilot end, and squeeze the bulb to force a small, quick stream of water through the radial holes above the magnet to shrink the insert. The weight of the tool often is sufficient to pull the insert from its counterbore, however, slight force may be applied by hand without pulling the magnet from the seat.

e. If the first attempt results in only partial removal of the insert, reheat the cylinder and repeat the removal operation. In a few cases it may be impossible to remove the insert completely by this method. If the insert can be moved enough to provide a gap above it, a positive expanding puller may be used.

Note

To avoid possible loss of the magnetic strength and to assure best operation of the insert removers, the magnets should be cooled between successive operations. Keep the faces of the segments clean to allow full contact with inserts.

CAUTION

Do not allow the remover tool to drop. Any sharp blow on the magnet may crack the brittle material

f. Clean and measure the removed seat insert diameter. Compare the measured value with the appropriate column in Table IX. Record standard or oversize designation of the removed insert, since the same oversize will be installed if the cylinder head counterbore is undamaged. The part number of each insert is acid etched on the insert face outside the seat. This is formed by adding P005, P010, P015, P020, or P030 to the standard size part number.

g. Bore the cylinder head counterbore to the proper size for the oversize insert to be installed, in accordance with Table IX. Notice that a tolerance of 0.002 inch is allowed in the counterbore diameter. While sizes within the range are permissible, the smaller is to be preferred, in order to secure the tightest fit consistent with safety.

Note

The intake valve seat insert has a small step on the outside surface. The larger diameter fits tightly in the straight counterbore of the head. The exhaust valve seat insert has a large step on the outer surface. Its smaller diameter fits tightly, while the larger end fits loosely in the stepped counterbore. Bore out only the smaller counterbore in the head.

h. Reheat the cylinder and head assembly to 301.6°C (575°F), allowing time to heat throughout, but not over 1 hour.

i. Remove the cylinder, and place it in the inverted position in the Group 4 cylinder head holding fixture.

j. Place the oversize seat insert on the shoulder of the proper Group 6 valve seat replacer with the chamfer side against the tool flange. Grip the insert by depressing the lever on the handle.

k. Insert the replacer pilot in the inner end of the valve guide, and quickly thrust the insert home. After a moment, release the grip lever, and rap the insert sharply with the tool to assure firm seating; then remove the replacer.

5–39. REFACING VALVE SEATS. Worn seats shall be refaced to a true surface, and with the seat angle specified in limit No. 12, Section X, with the minimum possible removal of metal. Soft abrasive stones are required to prevent burning the hard alloy seat inserts. The stones must be trued at frequent intervals and must operate in a stream of coolant liquid. During the refacing operation, the seat shall be inspected for correct angle and true circular shape by inserting the Group 6 valve seat blueing gage, with a very thin film of Prussian blue, oil base pigment on the gaging cone surface. Worn seats shall be checked for excessive width by observing whether the flat on the tool cone exposes the outer edge of the seat. If the flat comes within the seating surface, the seat is over width. It may be narrowed with a 70-degree stone one time only. Excessive depth of either valve seat will reduce the "dry" clearance required for proper operation of the hydraulic valve lifters beyond allowable limits. It is advisable to gage the depth from the mounting surface of the cylinder base flange to the circle on

TABLE IX VALVE SEAT INSERT AND COUNTERBORE DIAMETERS

SIZE (INCHES)	INTAKE VALVE SEAT		EXHAUST VALVE SEAT	
	INSERT DIAMETER (INCHES)	COUNTERBORE DIAMETER (INCHES)	INSERT DIAMETER (INCHES)	COUNTERBORE DIAMETER (INCHES)
Standard	2.528-2.529	2.517-2.519	1.796-1.797	1.787-1.789
0.005 oversize	2.533-2.534	2.522-2.524	1.801-1.802	1.792-1.794
0.010 oversize	2.538-2.539	2.527-2.529	1.806-1.807	1.797-1.799
0.015 oversize	2.543-2.544	2.532-2.534	1.811-1.812	1.802-1.804
0.020 oversize	2.548-2.549	2.537-2.539	1.816-1.817	1.807-1.809
0.030 oversize	2.558-2.559	2.547-2.549	1.826-1.827	1.817-1.819

any reground valve seat whose diameter is as shown below.

INSERT	GAGING DEPTH (INCHES)	GAGE DIAMETER (INCHES)
Intake Valve Seat	6.455-6.465	2.250
Exhaust Valve Seat	6.475-6.485	1.781

A special type of step gage is required for this inspection. The bridge must rest on the flat face of the base flange on opposite sides of the barrel and must clear the cylinder skirt. Gage stem holes in the bridge must align with the two valve guides. The stems must be machined with cone ends of the gaging diameter and seat angle and must be accurately ground to proper length so that their indicating ends will pass through the bridge holes and lie between upper and lower steps ground on the bridge when the seat is ground within limits.

5–40. REFACING VALVES. Worn valves may be refaced to a true surface and with the face angle specified in limits No. 19 and 20, Section X. Excessively warped valves must be discarded. Valve refacing will be performed in accordance with established procedures and with valve refacing equipment in general use, subject to the following restrictions and precautions:

a. Depth of tip regrinding and valve length must not exceed the "Maximum Replacement" values of limits No. 21 and 22, Section X.

b. The outer edge of the reground valve face must not cut into the rounded edge of the valve head.

c. Refinished faces of exhaust valves must not go deeper than the 0.031 inch original stellite facing.

d. The valve face must be flooded with a stream of coolant liquid throughout the regrinding operation to prevent overheating.

e. For tip regrinding, the valve stem must be guided in the proper machine attachment to assure a flat, square end. No tool marks shall remain on the finished tip. (Surface roughness should be 16 micro inches, R.M.S.)

f. Lap valves to seats in which they will operate. Obtain only line contact. Use fine grade lapping compound. Remove all traces of compound after lapping.

5–41. ROCKER SHAFT SUPPORT BOSS.

5–42. INSPECTION. Inspect excessively worn rocker shaft bores in cylinder head bosses to see if they are to be line reamed with the Group 4 rocker shaft support boss reamers, in order, to dimensions specified in figure 5–10.

5–43. REPLACEMENT. Drive in repair bushings to positions illustrated in figure 5–10, starting with those in the center boss. Insert these two bushings, in turn, between bosses, and insert the Group 6 remover and replacer through the outer bosses and into

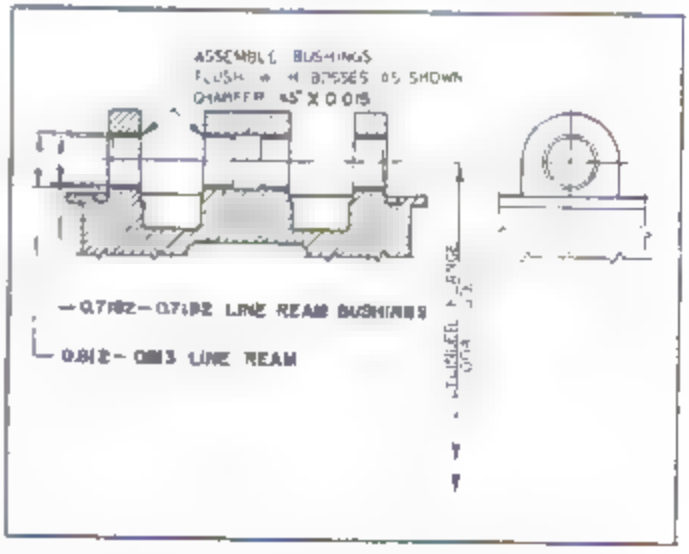


Figure 5–10. Dimensions of Rocker Shaft Support Bushings

them. Drive the center bushings in flush, as shown, then drive a bushing into each outer boss until flush with its inside surface. The bushings must not project into the valve rocker spaces between bosses. Line ream the repair bushings with the Group 4 rocker shaft bushing reamer, and inspect the finished bushing bore for compliance with limits specified in figure 5–10 and paragraph 5–06. Break sharp edges at the bushing bore ends approximately 0.010 inch (radius or chamfer). The bushings axis must be located within limits specified in the figure 5–10 and must not be askew in any plane relative to valve guide centers and the cylinder base flange. Finished bores must be free of tool marks.

5–44. VALVE ROCKER BUSHING.

5–45. INSPECTION. Inspect to see if rocker shaft should be replaced with a 0.005-inch oversize part. The rocker bushings must be reamed to fit the new shaft.

5–46. REPAIR. Use Group 6 cylinder head rocker shaft bore reamer of maximum size or an alternate reamer to secure the specified loose fit on the shaft. Limit No. 14, Section X, applies to oversize bushings and shafts, as well as to standard size parts. The reamed bushings should fit the new oversize shaft within the limits specified for new parts. Use the gage marked "0.005 inch Oversize" in the Group 6 rocker arm bushing gage set. The "Go" step should enter the bushing fully, but the "No Go" step should not enter at all. If the rocker shaft is to be standard size, and if the rocker bushings are worn so that the "Worn Bushing No Go" gage end of the Group 6 standard size bushing gage in gage set enters the bushing bores, or if the rocker shaft is to be oversize and the oversize bushings already installed are worn so that the "Worn Bushing No Go" end of the 0.005-inch oversize gage enters the bores, the bushings must be replaced and reamed to either standard or oversize, as required.

5–47. REPLACEMENT.

a. Place the support ring of the Group 6 rocker arm bushing remover and replacer on the arbor press and center the rocker on the ring.

b. Insert the shouldered end of the driver into the bushing and bring the ram down on its upper end. Make sure that the driver is square and bears equally around the bushing end.

c. Apply force to move the bushing out of the rocker.

d. Inspect the rocker bore and blow out any bronze chips. See that the oil groove is clean and check the drilled oil holes with a soft wire. Do not enlarge the squirt nozzle of intake rockers.

e. Dip the replacement bushing in engine lubricating oil, Specification MIL-L 2104, and place it on the driving end of the tool.

f. Place the rocker on the support ring, start the bushing into the rocker bore and square bushing and driver with the rocker.

g. Bring the ram down on the driver and press in the new bushing until its ends are projecting equally from the sides of the rocker.

h. Face the bushing ends flush with the sides of the rocker. Do not cut into the rocker metal. This operation may be performed by filing; however, end milling or facing with a fly cutter is preferable.

i. Ream the bushing to proper size to fit the rocker shaft to be installed in the cylinder. Use Group 6 rocker arm bushing reamers. Clamp the valve contact end of the rocker in soft vise jaws. Turn the rough cut reamer through the bushing and withdraw with minimum turning. Next, ream the bushing bore to final size with the finish reamer. If the rocker shaft is 0.005-inch oversize and if a new Group 6 cylinder head rocker shaft bore reamer is available, the replacement bushing may be reamed to oversize with this tool. Otherwise, a reamer of correct size to provide the correct bore diameter must be employed.

j. Gage the finished bushing bore with the Group 6 standard or oversize rocker arm bushing gage as applicable. Use the "Go" and "No Go" step gage end. The "Go" gage should enter the bushing fully but the "No Go" step should not enter at all.

5–48 CYLINDER HEAD FIN REPAIR. Removal of fin area to the extent of 10 percent by breakage or by drilling out to stop cracks is permissible. Broken fins should be filed carefully to round sharp edges along the break. Do not remove metal unnecessarily. If a crack from the edge of a fin toward the root is found, it may be stopped by drilling out a portion extending inward beyond the end of the crack and rounded to approximately 1/4-inch radius at the point. Use a Group 4 cylinder head fin repair drill and guide for this purpose. The guide slides over the fin like a clothes pin so that the drill will cut the full thickness of the fin. If a crack extends to the head surface, the damage cannot be arrested and the cylinder assembly must be discarded.

5–49. PISTON ASSEMBLY.

5–50. INSPECTION. Inspect the following features of each piston assembly in the manner indicated.

a. Inspect the piston skirt for heavy scoring and galling.

b. Inspect all surfaces for necessary cleanliness. Stains may be permitted, though all carbon deposits, oil "varnish", and loose material should be removed. Inspect oil drain holes at the bottom of the third ring groove for cleanliness.

c. If a crack is suspected, etch the area locally as described in paragraph 5–3.

d. Inspect the piston pin bore for excessive wear, using Group 5 piston pin hole gage. The gage is marked "Standard" (for pistons fitted with standard size pins). The gage has a worn hole "No Go" end only.

e. Measure the piston skirt diameters below the third ring groove and at the bottom in a direction at right angles to the pin bore. The skirt is tapered, its larger diameter being at the bottom. The measured diameters should be recorded for comparison with cylinder bore diameters to determine whether cylinders require regrinding.

f. Obtain the new set of rings to be used with each piston. Place each ring, individually, in the Group 5 piston ring gage and measure the gap. (See figure 5-11.) The gage ring has a center groove separating the standard size diameter side from the 0.005-inch oversize diameter side. If cylinder bore has been, or is to be, honed to 0.005-inch oversize, use 0.005-inch oversize rings and check them in the oversize side of the gage. Gaps must be within new part limits specified for ring in cylinder barrel. (See limits No. 30, 31 and 32, Section X.)

g. Install the set of rings in the piston. Using a standard thickness gage, measure the piston ring side clearances, and compare measured values with limits No. 27, 28 and 29 in Section X. (See figure 5-12.)

Note

After a set of rings has been inspected for correct fit in each piston, they should remain in place to avoid mixing. If cylinder barrels are to be honed or reground, the piston rings for each should be checked for gap (in the refinished barrel at a point even with the base flange) against the "Replacement Maximum" value. It is preferable that gaps remain within the "New Part" limits. It is for this reason that 0.005-inch oversize rings are supplied for installation with standard pistons in honed barrels. It is not necessary to coat piston rings or pistons with the corrosion preventive mixture after inspection. Rings are protected by Parko Lubrite coating (top) and by tin plating (second and third). Wrap the assembly of piston pin and rings to keep out grit. Original type piston pins were equipped with loose fitting end plugs of aluminum. If plug ends have worn beyond the limits specified as "Replacement Maximum" in limits No. 36 and 33, Section X, the plugs may be replaced as long as stocks are available. Current type pin plugs are pressed in and are not replaceable.

5-51. REPAIR. Stone light nicks and scores with a flat hard Arkansas stone. If the piston head has been battered, if it has a great number of nicks, or if the walls are heavily scored, the piston must be discarded. If piston ring grooves are worn to the extent that the ring side clearances specified as "Replacement Maximum" in Section X cannot be obtained with standard width rings, the piston cannot be repaired since over-width rings are not available. Piston pin plugs of the original, loose fitting type may be replaced with new parts if excessively worn on the bearing diameter or ends. Current production pins have a single plug which projects from both ends and is hot forged in place. These plugs cannot be replaced. If these are excessively worn or loose, the pin and plug assembly must be discarded.

Figure 5-11. Inspecting Piston Ring Gap

Note

Pistons are balanced in sets by weight at the factory. If a piston is replaced the new part must weigh within 1/2 ounce of the heaviest and lightest pistons in the engine set.

5-52. CRANKSHAFT.

5-53. INSPECTION.

a. Inspect for excessive wear of propeller flange and for thread condition, tightness, and seating of propeller bolt bushings.

b. Inspect oil tubes for cleanliness and tight installation.

c. Inspect dynamic damper pin bushings for excessive wear.

d. Inspect counterweight bushings for tight installation and wear. Check for wear in the pin retaining plate bore.

e. Inspect damper pins for wear and scoring.

f. With shaft support on "V" blocks at front and

Figure 5–12. Inspecting Piston Ring Side Clearance

rear journals, check run out at center journal and front end. (See figure 5–13.) Check run out of a flanged shaft near perimeter on face of propeller flange.

Note

Crankshaft counterweights may be ground at the ends. This shall not be cause for rejection, since grinding was employed in early production parts as a method of balancing the assembly. The correct side location and orientation of counterweights must be preserved to maintain the original balance, whether ground or not.

5–54. REPAIR. When the crankshaft main journals and/or crankpins have worn to the extent that measured diameters are less or out-of-roundness more than permitted by limits No. 47, 48, 49 and 50, Section X, or when end clearance specified in limit No. 46 (with a new main-thrust bearing) is in excess of the "Replacement Maximum" values, the crankshaft may be repaired by grinding journals, crankpins, and thrust flanges to undersize dimensions specified on the engine manufacturer's drawing, No. 531008. The reground crankshaft must be installed with 0.010-inch undersize bearings. The following requirements must be observed.

a. Center a flanged shaft on the chamfer inside the front hub and the chamfer at the rear end surrounding the tapped hole for the starter jaw retaining stud, which must be removed for this operation.

b. For grinding crankpins, offset grinder centers two inches from axis of rotation.

c. All journals and crankpins must clean up within a range 0.010 inch smaller than diameters specified in limits No. 49 and 50 for new parts. Allowance must be made for final lapping.

d. Leave 1/4-inch length from rear end of rear journal original diameter for gear pilot.

e. Maximum out of roundness of new journals and crankpins specified in limits No. 47 and 48, Section X, must not be exceeded.

f. Taper in diameter of any crankpin or journal from end to end must not exceed 0.0005 inch and must be uniform.

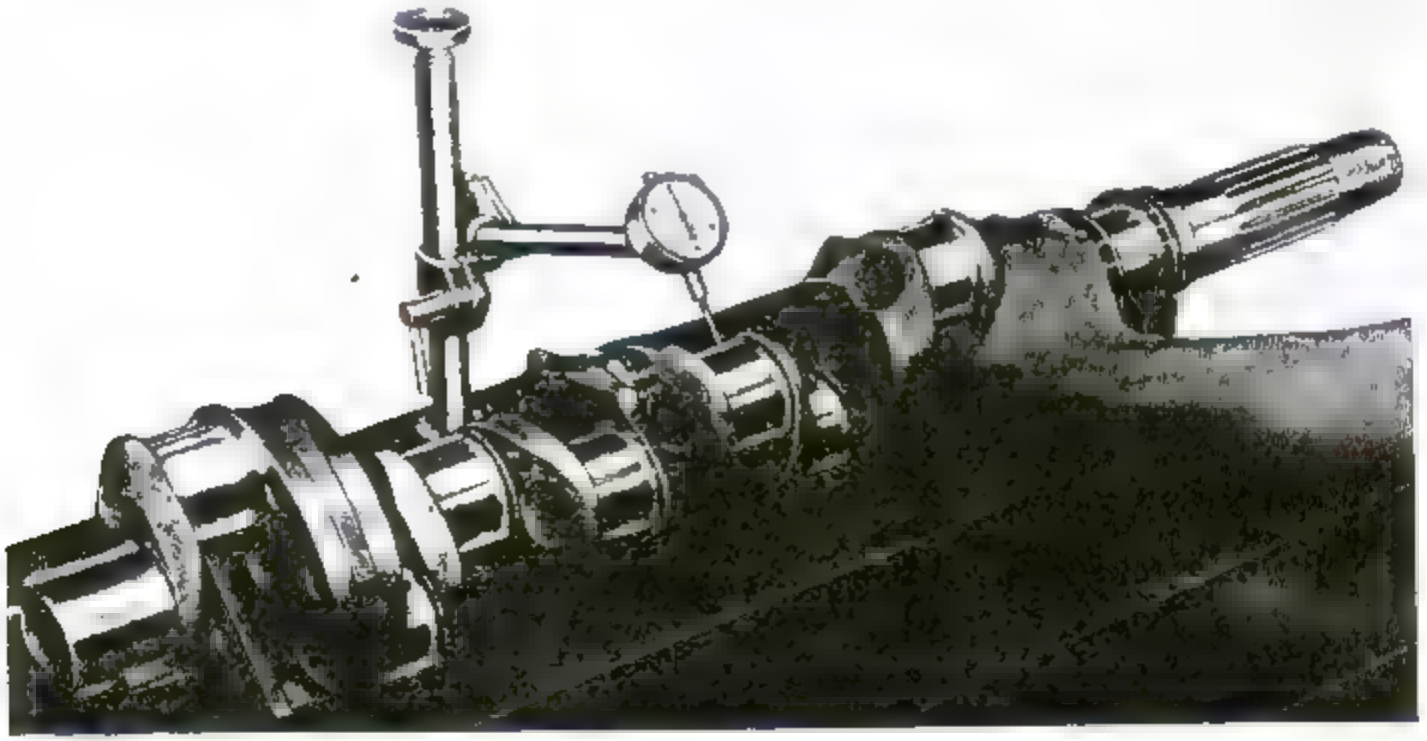


Figure 5–13. Inspecting Crankshaft Alignment

g. Spacing of reground thrust and anti-thrust flanges shall be 1.710-1.714 inches. (Undersize bearings allow for this spacing.)

h. Fillets at ends of all crankpins and journals must blend smoothly into adjacent surfaces, except that grinding reliefs between fillets and crankcheeks shall not be completely removed.

i. Fillet radii, after regrinding, shall be within the following limits:

Between front journal and thrust flanges, 0.145-0.160 inch.

Ends of all other main journals and all crankpins: 0.219-0.250 inch. (A 0.190 inch radius gage placed in any position on these fillets must contact at one point only.)

j. Fillets and journals must show no grinding marks.

k. After grinding and before lapping journals and crankpins, the shaft ends must be tin flash plated for a distance of 2.74 inches from the front end of a flanged shaft, and on the flat rear end and threads of the rear main journal. Remove propeller bolt bushings from flanged shafts and mask flange holes before plating. Remove masks after plating.

l. The reground shaft shall be nitrided to produce a case depth of 0.015-0.025 inch.

m. After nitriding, the main journals and crankpins must be lapped to specified size and with maximum surface roughness of six micro inches R.M.S. Tin or copper plating must be stripped from front and rear ends before lapping.

n. The resized shaft shall be checked for run out at center journals while supported at front main-thrust and rear journals (refer to limit No. 51) or on the front hub and the face of the propeller mount flange.

o. The resized shaft shall be reinspected magnetically for grinding cracks.

p. After inspection, the undersize shaft shall be marked for identification, in accordance with pertinent procedures.

Note

Crankshafts reground to 0.010 inch undersize by the engine manufacturer are marked by acid etching the undersize designation "0.010 US" on the front surface of the front (anti-) thrust flange.

5–55. DAMPER PIN BUSHING.

5–56. INSPECTION. Inspect crankshaft or counterweight damper pin bushings to see if they have worn to permit pin diametrical clearance, in any direction, to exceed the "Replacement Maximum" value specified in limit No. 56, Section X.

5–57. REPLACEMENT.

a. Chill the worn bushings with dry ice briefly. Do not heat the crankshaft. Counterweights may be heated to 149°C (300°F), if desired, before chilling bushings.

b. Use a small screw puller to withdraw the worn bushings, or drive them out with a brass drift.

c. Inspect the crankshaft or counterweight bushing bore for scoring. Smooth any roughness.

d. Measure the hole diameter and compare with the outside diameter of the replacement bushing. The hole diameter must be smaller than the bushing, at room temperature, by the amount of interference (tight fit) specified for new parts in limit No. 54 or 55, as applicable.

e. Dip the replacement bushing in engine lubricating oil, Specification MIL-L-2104, grade 50, and press it into the crankshaft or counterweight bore. Crankshaft bushings must be installed so that their rear edges are 0.015 to 0.025 inch forward of the rear surface of the crankcheek extension. Counterweight bushings must be flush with the slot side walls.

Note

Damper pin bushings shall not be ground on the inside diameter after installation.

CAUTION

Crankshaft counterweights are balanced with the crankshaft assemblies. They cannot be interchanged between sides of the shaft or reversed in position or interchanged between crankshafts without destroying the balance of the assembly.

5–58. PROPELLER BOLT BUSHING.

5–59. INSPECTION. Check the thread of any propeller bolt bushing in a flanged crankshaft to see if it is damaged.

5–60. REPLACEMENT. Press out damaged bushing with a suitable drift, while the shaft propeller flange is supported in an arbor press. Obtain a standard size replacement bushing, and dip it in lubricating oil, then press it into the vacant hole with the same tools, aligning the hex the same as the other bushings.

5–61. CONNECTING ROD

5–62. INSPECTION. Inspect bearing cap bolts for elongation (by comparison with new parts) and for thread condition. Check fit of nut threads on bolt ends and positions of cotter pin holes when nuts are tightened to specified torque on the assembled rods. Cotter pin holes must lie within the nut slots. Test alignment of the connecting rod big end bore (without inserts) with piston pin bushings which have passed

dimensional inspection or have been installed as replacements. This inspection may be performed by inserting push fit arbors in the big end and bushing and placing the big end arbor in "V" blocks on a surface plate so that the bushing arbor rests on two parallel blocks, accurately ground to uniform height. A thickness gage may be used to test for clearance under either end of the bushing arbor, indicating twist or bushing misalignment. The rod may be swung to the upright position in the "V" blocks and a surface gage and dial indicator passed over the bushing arbor to test for bushing and bearing convergence. (Refer to limit No. 42, Section X.)

5–63. Inspect to see if piston pin bushings are worn so that their diametrical clearances with the corresponding piston pins exceed the "Replacement Maximum" value specified in limit No. 37, Section X.

5–64. REPAIR. Stone nicks on machined surfaces. Replace bearing cap bolts or nuts which are defective in any way.

5–65. REPLACEMENT.

a. Obtain a suitable support ring of the proper diameter to pass the bushing and to support the connecting rod boss. Center it on the nearest size slot of the arbor press table.

b. Insert the Group 3 connecting rod bushing remover and replacer in the worn bushing, and lay the rod boss end on the support ring. Bring the ram down on the tool end and apply force to push the bushing out.

c. Inspect the connecting rod bore for cleanliness, and remove any bronze chips. It is not possible to compare the hole diameter with the split bushing diameter, due to the spring of the bushing.

d. Coat the replacement bushing with engine lubricating oil, Specification MIL-L-2104, grade 1065, and place it on the removing and replacing tool end.

e. Place the bushing on the rod boss in such a position that a radial line from the bushing center through the split makes an angle of approximately 45 degrees with the center line extending toward the big end of the rod, as shown in figure 5–14.

f. Bring the ram down on the tool, and square the bushing and replacing tool with the rod bore. Apply pressure to drive the bushing into place. Watch for possible misalignment, which will peel off bushing metal on one side. Drive the bushing in flush with the end of the rod boss.

g. Ream the new bushing using Group 3 connecting rod bushing reamer to size to fit the piston pin installed. For this operation, the big end of the rod assembly, without bearing inserts, must be held on a snug fitting arbor which has been located and clamped with its axis accurately parallel to the reamer. The distance between centers of the big end bore and the bushing bore must be between 6.627 and 6.623 inches. This spacing will be maintained automatically if the bushing bore is concentric with the rod bore, unless the rod has been deformed. Ends of connecting rod bushings should not be machined, except to break sharp edges at each end of the bore 0.015 in. x 45° if the original chamfers were completely removed.

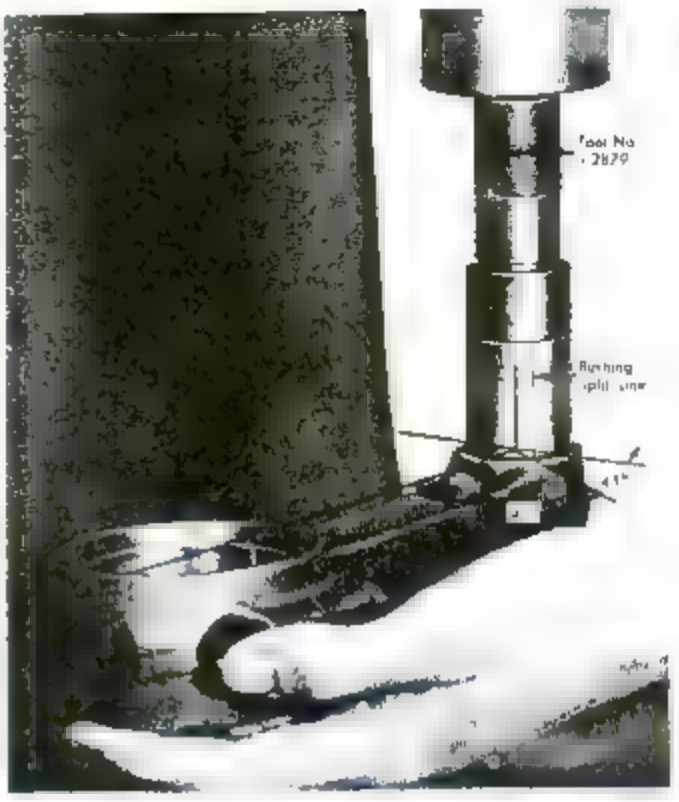


Figure 5–14. Installing Connecting Rod Bushing

h. Use the Group 5 connecting rod bushing gage to check replacement bushing bore diameters.

i. Check all replacement bushings for twist and convergence relative to the big end bore in accordance with the procedure explained in paragraph 5–62. If a special connecting rod inspection fixture is available, it may be used in lieu of the prescribed method.

5–66. All connecting rod crankpin bearing inserts must be replaced at each overhaul. When the replacement set is drawn from stock, make sure that the inserts are all of standard size or all 0.010 inch undersize, as required by the status of the crankshaft. All inserts have their part numbers lightly stamped on the back sides, near one end. The inserts will be installed during assembly of subassemblies.

CAUTION

If any connecting rod assembly is replaced, the entire set for that engine must be weighed. The permissible difference in weight between the lightest and heaviest rod assemblies in any engine set is 1/4 ounce.

5–67. CAMSHAFT AND GEAR.

5–68. INSPECTION.

a. Inspect visually for scored and roughened camshaft journals and lobes, pitting or excessive wear along toes of lobes and foreign deposits on any surface. If the tapered lobes appear to be worn, measure the lift at the center of each lobe by mounting camshaft between bench centers, and using a dial indicator, Federal Model D81S or equal, which has a 1/2-inch stroke. The axis of the dial indicator must be perpendicular to, and intersect, the camshaft centerline.

b. Check fit of gear on shaft flange.

c. Inspect shaft and gear retaining screw threads and screw hex flats for deformation.

d. Measure camshaft journals for diametrical wear. If crankcase bearings are within worn part limits and journals are not appreciably worn, the fit (limit 64 in Section X) will be within the "Replacement Maximum" value. Appreciable journal wear may cause an excessive clearance. In case of doubt, measure bearing diameters and compare with journal diameters.

e. If the camshaft has been, or may have been, dropped or subjected to severe shock, measure its center journal eccentricity by dial indicator with shaft supported on front and rear journals in matched "V" blocks or mounted between bench centers.

f. Inspect camshaft gear teeth for scoring, feathering, pitting, and profile wear. Inspect pilot counterbores for nicks and roughness

5–69. REPAIR. Camshafts are not subject to repair except by stoning of minor nicks and smoothing lightly scored journals.

5–70. HYDRAULIC VALVE LIFTERS.

5–71. INSPECTION. Inspect for visible defects and test operation in the following manner:

a. Observe cam follower face for evidence of scoring, spalling (pitting), or groove wear. (See figure 5–15.)

b. Inspect shank surface for scoring and galling.

c. Start the dry plunger into the cylinder of the hydraulic unit. Push it inward and release it very quickly. The compression of air in the dry cylinder should make the plunger kick back instantly. If it does not return, continue checking as outlined in steps d and e.

d. To check for a leaking check valve, close the end of the inlet tube with a finger, and again depress the plunger and release it. If the valve was at fault, the plunger will kick back; if not, it is worn excessively.

e. If the plunger returned in step d, but not in step c, the valve is dirty or the seat is worn. Clean parts again and repeat the test.

5–72. REPAIR. Parts of Wilcox-Rich valve lifters are not repairable. If any part of the hydraulic unit is defective, as determined by the operational check specified in paragraph 5–71, the entire unit — but not necessarily the body — must be replaced. Lifter bodies may be replaced, if worn, pitted, or scored, independently of hydraulic units and pushrod sockets. Sockets may be replaced independently. When replacing complete valve lifters or bodies, make sure that the proper type is used to suit the camshaft to be installed. (Refer to note, paragraph 2–29.)

5–73. CRANKCASE ASSEMBLY

5–74. REPAIR. Stone all nicks on parting faces and other machined surfaces. Replace all damaged studs in accordance with instructions in paragraphs 5–13 through 5–15. (Refer to Table VI for setting heights.)

CAUTION

If any cylinder pad stud was broken, all studs in that pad must be replaced, and the two through holes which attach that cylinder and pass through holes of that pad also must be replaced.

5–75. Very light scoring in the valve lifter guide bores may be removed with crocus cloth wrapped around a hardwood dowel in a helical pattern. A 1/2-inch diameter hard Arkansas stone also may be used to dress down the raised metal. It is essential that such treatment be minimized to avoid enlargement of the bores. If oil holes are not equidistant from the outer ends of guides in early production crankcase castings, those which are too far from the camshaft to align with lifter body oil grooves — when the lifters are in their outermost positions (on toe of cam) — may be extended toward the camshaft by drilling an offset at the inner ends with a drill guide made up for the purpose, or they may be extended inward with a 1/4-inch diameter rotary file of long, tapered pattern. After any such reworking, all chips and abrasive must be blown out.

5–76. Deformed engine mount bracket bushings may be pressed out with an arbor press and suitable driver. Smooth any score marks in the bracket bore. Press in the new bushing with a film of anti-seize compound on its cylindrical surface. The bushing flange must seat on the lower side of the bracket boss

5–77. If the lower rear hole in the mount bracket pad of the crankcase is machined for a 3/8-inch through bolt, and the bracket to be installed is machined for a 5/16-inch through bolt, attach the engine rear mount brackets in place on the two studs and install the 5/16-inch through bolt in the lower front hole. Line ream the other bolt hole to 0.4062 inch diameter for a

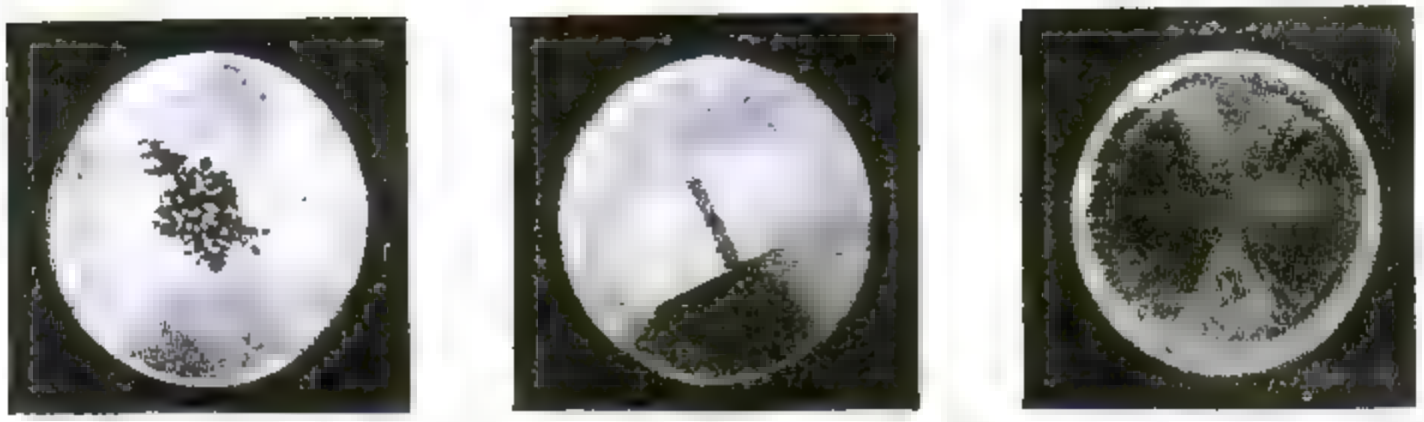


Figure 5–15. Defects of Lifter Face

3/8-inch diameter through bolt. When the hex head through bolts require replacement, refer to TM 1-2R-0470-4 to obtain the part number of the correct through bolt to be installed.

5–78. ACCESSORY CASE

5–79. INSPECTION

a. Inspect the front and rear half castings for cracks, tapped hole thread damage or enlargement, flatness and smoothness of parting flanges, tightness and smoothness of bushings, smoothness of accessory and adapter pads, tightness of dowels and studs, damaged stud threads, bent or elongated studs, scored or roughened oil seal counterbores, removal of cleaning compound residues and other foreign matter, and clear channels in all oil passages, drains, and vents.

b. It will be necessary to pressure flush the oil passage networks to assure removal of sludge from grooves surrounding bushings. Inspection must check solvent flow from all bushings after such flushing at 10-20 psi.

c. Inspect all adapters for clear oil holes and grooves, if any, tightness and smoothness of bushing bores and faces, stud condition, oil seal counterbores, if any; and parting surface condition.

d. Measure all bushing bore diameters and compare with gear shaft diameters. Mark any excessively worn bushing for replacement.

e. Inspect the two aluminum gear bushing plugs, if used, and the flanged, tubular bushing plug for damage incurred in handling.

f. Inspect all gear teeth for cracks, chipping, pitting, and visibly worn profiles. Inspect gear shafts for cracks, scores, pitting, and visible wear and shaft splines for cleanliness and damage. Look for capped steel oil plugs in most accessory drive gears. They must remain tight.

g. Inspect the oil filler spout assembly for damage such as crushing, bending, warped parting flange, looseness of neck, rough washer seats, cracked casting, and inoperative cap locking device. If the casting is damaged beyond repair, discard the spout assembly.

h. Inspect all pipe plugs, the drain hose nipple, and all attaching nuts for thread damage, rough faces, deformed wrench flats, cracks, and foreign deposits. Inspect drain hose clamps for cracks and deformation. Discard all defective parts in this group.

i. Inspect the generator gear aluminum thrust washer for wear, bending, and roughness, and the Truarc retaining ring for deformation.

j. Inspect all accessory pad covers for warped gasket surfaces, cracks, and rough washer seats.

k. Check bushing bore locations, alignment, bore diameters, bushing face locations, squareness of faces, and finish of machined surfaces using appropriate fixtures, arbors, surface plates, and gages.

5–80. ASSEMBLY. Replace any defective studs in accordance with instructions in paragraphs 5–13 through 5–15. (Refer to Table VII for setting heights.) Stone any nicks on machined parting surfaces or accessory mount pads. Use crocus cloth carefully to smooth any scores in oil seal recesses. Stone any nicks or scores on gears or bushing oil plugs. Clean out damaged tapped holes with proper size taps (marked "CG"), removing the least possible metal. Replace any of the case or accessory attaching nuts, washers, or bolts and any pipe plugs which have been damaged.

5–81. OIL FILLER SPOUT. Cut off the deformed steel filler neck below the bulge and collapse the remaining sleeve with pliers for easy removal. If the spout casting bore is rough, smooth it with crocus cloth. Press a new filler neck into the spout casting while the latter is firmly bolted on a flat metal surface of an angle of 45 degrees to the arbor press table. After such repair work, recheck flatness of the spout parting flange. If necessary, restore flatness of the

gasket surface by lapping on a flat plate, using fine grade lapping compound. After lapping, flush away all abrasive particles with mineral spirits, applied by pressure spray gun or with a paint brush. If the spout casting is cracked or otherwise damaged beyond repair, as described above, discard and replace the assembly.

5–82. SPRING CLIPS. If the oil filler neck is not equipped with spring clips to retain the cap, drill two exactly opposite rivet holes with a No. 7 twist drill on a circle 1-1/6 inch below the top of the neck and on a center line of the circle which bisects the two cut-outs for cap locking lugs. (Refer to Continental Motors Corporation drawing No. 532540, change "D".) Use two round head steel rivets to attach the hinge plates of two spring clips. If original spring clips on the filler neck have been broken or deformed, shear the rivets and rivet new clips to the neck.

5–83. BUSHING REPLACEMENT

a. Remove excessively worn bushings from the accessory case halves and accessory adapters with positive spread screw pullers or by machine cutting to remove the flanges, boring the bushings to thin shells and collapsing the remaining bronze material with long nose pliers for easy withdrawal. When a bushing is bored out, endeavor to maintain a uniform wall thickness.

b. Inspect vacant casting holes after bushing removal, and use crocus cloth with care to remove the raised edges of any scores.

c. Press in replacement bushings after dipping them in clean engine lubricating oil, Specification MIL-L-6082. The castings need not be heated for this operation. If any bushing appears to fit too tightly or too loosely, remove it and check the measured interference against the appropriate limits in Section X. The arbor press employed in such operations must have a smooth table of such dimensions as to support the casting square with the ram and to prevent damage to machined surfaces. The ram should not contact the bushing flange directly unless its end is perfectly smooth and flat. Bushings may be driven into place with suitable drifts and a mallet when no arbor press is available. In any event, the bushing must be driven or pressed in square with the casting hole to avoid peening of metal. The bushing flange must lie in contact with the casting all around. An oil groove is provided in either the bushing or its casting hole so that oil holes through bushing walls need not align with casting feed holes.

d. Replacement magneto adapter assemblies and generator adapter assemblies are supplied with unfinished bushings. If any of these are to be installed or if an adapter bushing has been replaced, it will be necessary to attach the adapter to the assembled accessory case halves with the appropriate attaching washers and nuts, omitting the gasket, before boring the bushing. In addition, it is necessary to replace the front magneto gear bushing in the case front half when the corresponding magneto adapter or adapter bushing is replaced and to line bore the two bushings. It is also necessary to replace both front and rear bushings which support any other gear when either is replaced and to line bore them in the assembled case.

e. A tolerance of 0.002 inch in all planes is allowed on squareness of finished bushing bores with the machined front and rear surfaces of the assembled case halves, and the same tolerance is allowed on parallelism of finished bushing flange surfaces to the same case surfaces. Mount a dial indicator on a rigid support from the boring bar or spindle at a radius of 10 to 12 inches and establish squareness of the table or angle bracket on which the case assembly will be clamped for boring and facing operations.

f. Assemble the case halves, omitting the accessory case front to rear gasket. Install the appropriate attaching parts, except nut locks. (See figure 4–1, indexes 6 and 7.) If desired, the front half casting may be clamped on the boring machine table before the rear half is attached to it, or the assembled case may be clamped with bolts. (See figure 4–1, index 8.) Use plain washers or suitable soft metal or fibre pads to protect the castings from damage at clamping points.

g. If a magneto or generator adapter bushing has been replaced, install the adapter, omitting its gasket, and install appropriate attaching parts, except nut locks. (See figure 4–1, indexes 2 and 12.) If the generator adapter or upper hydraulic pump drive bushings have been replaced, and unless a special boring machine is available, it will be necessary to make a second set up to bore these after other bushings have been bored from the rear side of the case.

h. If the oil pump body bushings are replaced the oil pump gear bushings in the case rear half also must be replaced and line bored with them, and vice-versa. The fuel pump drive and idler bushings and the lower tachometer drive bushing in the rear half do not align with bushings in the front half, hence they may be replaced independently of others. All of these bushings must be bored from the front side of the case rear half with the front half removed, therefore, they should be bored after completion of boring all aligned bushings in the two halves and the generator drive bushing. This may be done when the rear half is set up to face rear bushing flanges. Attach the oil pump body with appropriate parts, except nut locks. (See figure 4–1, index 1.)

i. Refer to figure 5–16 for limits on boring centers of all accessory case, adapter and oil pump bushings. Bushing centers must be held within these limits to maintain the back lashes of serviceable gears within replacement maximum limits. Observe that bushing centers are measured from the vertical center line of the case and from the horizontal center line of the front half holes for crankcase dowels in the same

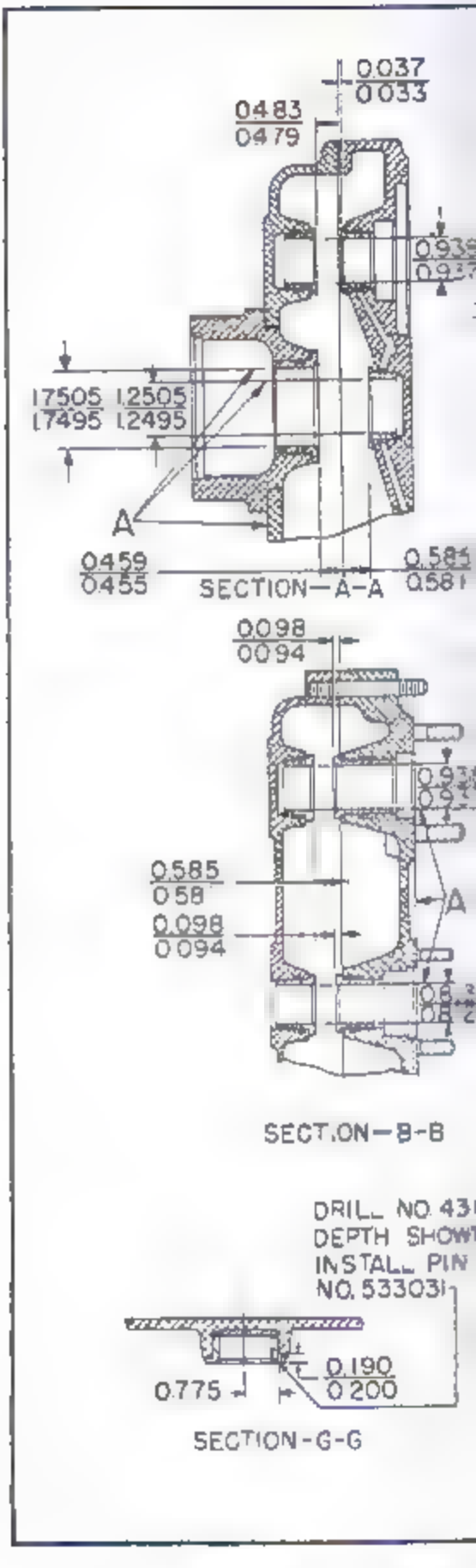
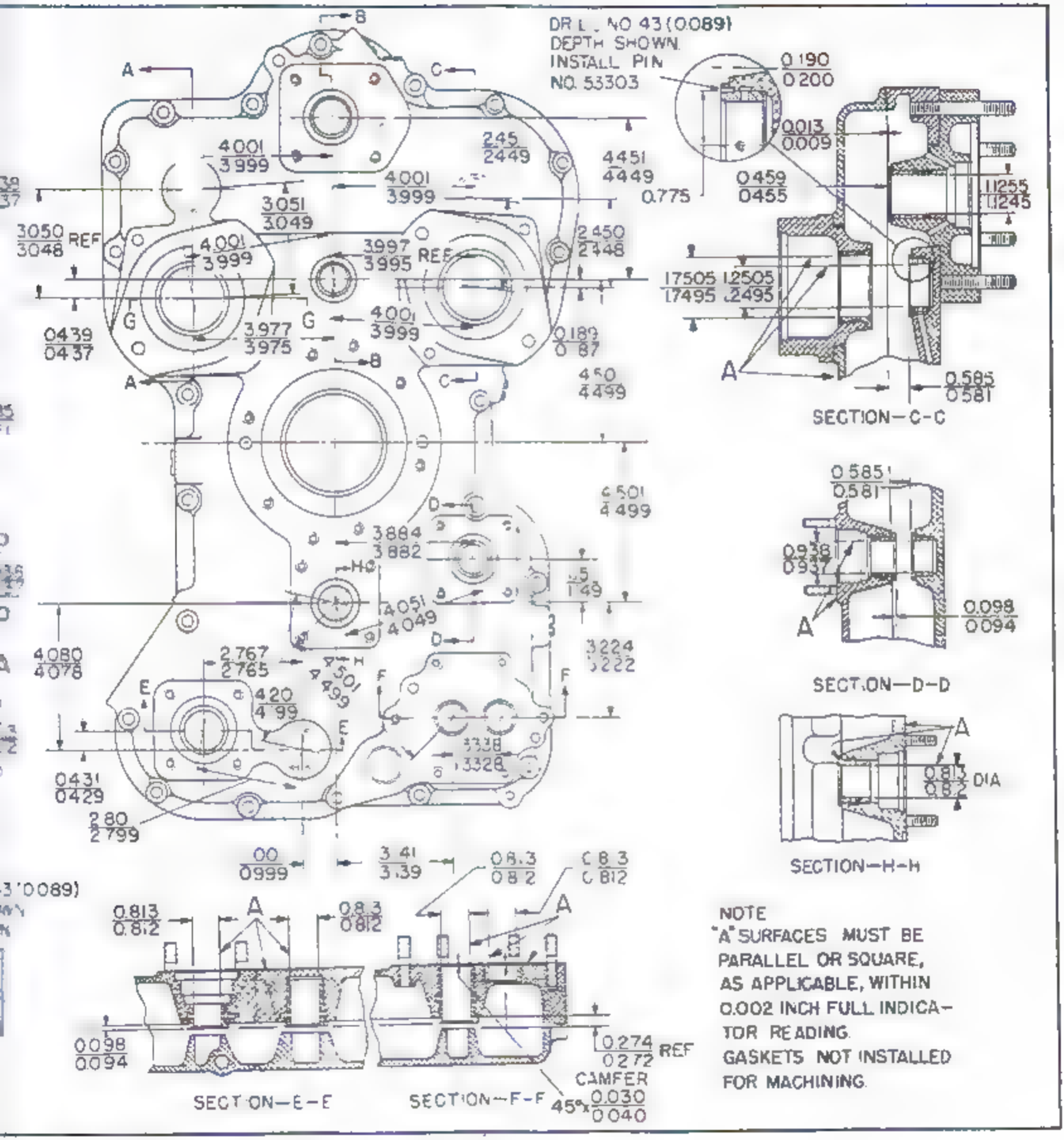


Figure 5–16. Bearing and



nd Facing Dimensions for Accessory Case Bushings

horizontal plane as starter adapter pad dowels). The counterbores in the starter adapter mount pad are centered at the intersection of the vertical and horizontal reference planes and provide a reference point for indexing the boring machine table. Reference dimensions shall be used to locate the case relative to the boring axis. Bushing center to center limits shall be used to inspect the finished bores and may be used, when suitable arbors are available, to check the case position before boring. Bore diameters of finished replacement bushings shall be within limits specified in figure 5–16. The finished bushing bores must be free from tool marks.

j. When all accessible replacement bushings have been line bored, remove the accessory case rear half, and face flanges of front half bushings and the generator adapter bushing, if replaced, square with the front parting surface and to dimensions specified in figure 5–16. Finished faces must be free of tool marks. Break all sharp edges approximately 0.010 inch.

k. Clamp the accessory case rear half on a support which is square with the boring axis, with magneto adapters and oil pump body (if their bushings were replaced) still attached. Bore any of the fuel pump drive, fuel pump idler, or oil pump gear bushings which were replaced. (Refer to figure 5–16 for center locations and diameters.)

l. With the same set up as in the preceding step, face all replacement flanged bushings in the rear half and adapters. (Refer to figure 5–16 for facing dimensions.) Break all sharp edges approximately 0.010 inch.

m. Do not disassemble the front and rear case and adapter assemblies until the work has been inspected. Disassembly will be performed during inspection after alignment has been verified.

n. Following disassembly of attached parts, blow machining chips from all oil passages with dry compressed air.

5–84. INTAKE AND OIL DRAIN MANIFOLD.

5–85. INSPECTION. All machined surfaces shall be inspected for deep scratches, nicks, and cracks. Inspect the four studs for bending, elongation, tight installation, and thread condition. Inspect the two tapped holes for thread condition and enlargement due to excessive tightening of fittings. If a manifold casting is known to have received a severe shock — as in a "belly landing" — or, if an engine fails to pass test — due to excessive spark plug fouling which cannot be corrected by replacement or repair of cylinders — then the manifold should be subjected to a pressure test in a water tank. This test may be performed by sealing the front and rear oil inlet holes with rubber gaskets and backing plates attached by bolts, attaching a low pressure air hose to the rear, tubular oil outlet with an adapter and hose clamps, and submerging the casting. Air pressure in the line should be maintained between 25 and 35 psi. Any bubbles rising from the casting continuously will indicate a crack between the air and oil passages and indicate an unserviceable manifold.

5–86. REPLACEMENT. Replace defective or unserviceable manifold.

5–87. INTAKE TUBES.

5–88. INSPECTION. Inspect all tubes for cracks, abrasion and true shape of the ends. It is imperative that tube ends be perfectly round and free of joggles, peening and enlargement.

5–89. REPLACEMENT. Replace defective or unserviceable intake tubes.

5–90. OIL PUMP.

5–91. INSPECTION

a. Inspect oil pump body gear bushings for excessive wear.

b. Inspect gear chambers for scoring, and check body parting surfaces for warping.

c. Inspect gear teeth for nicks or scoring.

d. Inspect oil pressure relief valve parts for scores, nicks, and weak or distorted springs. Check for free sliding of the valve plunger in the sleeve.

5–92. REPLACEMENT. Oil pump body gear bushings, when excessively worn, may be bored to a thin shell which can be collapsed with a pointed instrument and long nose pliers for easy removal. Smooth the body holes with crocus cloth if necessary. Dip the new bushings in engine lubricating oil, Specification MIL-L-6082, and press them into place with an arbor press or drive them in squarely with a mallet and a suitable installing drift. The bushings must be line bored with accessory case replacement bushings, as described in paragraph 5–83. After removal of the pump body, face the two shaft bushings exactly flush with the impeller chamber end surfaces without cutting into the pump body metal. Break sharp edges.

5–93. Badly scored pump bodies cannot be repaired. Scoring often occurs in the gear chambers, which cannot be resurfaced without enlargement and loss of pumping capacity. Slightly warped body parting surfaces may be lapped on a flat plate. Use fine grade lapping compound and remove no more metal than necessary. Flush away all abrasive particles with safety solvent, Specification MIL-S-18718. Measure the resulting pump gear end clearances, with the gears in place, by inserting thickness gages under a ground flat bar placed on the parting flange surface. (Refer to Section X.)

5-94. Stone down any nicks on pump gear teeth with a hard Arkansas stone. Do not use a coarser abrasive.

5-95. Replace any oil pressure relief valve plunger which is scored or nicked and any lock nut, adjusting screw, or cap whose thread or hex is damaged by more than small nicks. Stone down small irregularities, and check the thread fits. Replace the springs if they were discarded because of weakness or if they are chipped or cracked. Replace valve plunger or relief valve sleeve as necessary to maintain the specified clearance

5-96. DIMENSIONAL INSPECTIONS.

5-97. MAINTENANCE OF FITS. All tight fits, clearances, spring pressures, and tightening torques shall be maintained within the limits specified in the Table of Limits, Section X.

5-98. DISPOSITION OF REJECTED PARTS. Parts whose critical dimensions have worn beyond allowable limits shall be replaced if they cannot be returned to serviceable condition by one of the following methods:

a. Replacement of inserts of standard or available oversize

b. Grinding or honing to fit standard size mating parts within the "Replacement Maximum" limits.

c. Grinding, honing, boring, or reaming to fit available oversize mating parts within limits specified for new parts.

d. Installation of available inserts to provide fit specified for new parts with standard or oversize mating parts.

5-99. FIT OF NEW AND OVERSIZE PARTS. In the Table Of Limits, Section X, figures in the "Minimum" and "Maximum" columns under the heading "New Parts" indicate — in decimal parts of an inch — the values of clearances and interference (tight) fits at room temperature obtained when new mating parts are properly installed together. These values also apply to fits to be obtained when the female part is honed, ground, bored, or reamed to the proper size to fit a new oversize male part or when a female insert is installed and reamed or broached to the proper size to fit a new, standard size or serviceable, used male part.

5-100. FIT OF USED PARTS. Clearances between running parts which do not exceed the values specified in the "Replacement Maximum" column of Section X permit the parts to be reinstalled in the engine. If the limit is exceeded, the part which is further from original size shall be replaced. The replacement part must fit the mating part within the "Replacement Maximum" limit.

5-101. FIT OF INSERTS. Replacement inserts installed in place of worn inserts must have the same interference, at room temperature, with the recess in which they are screwed or pressed as that specified for new parts. If an interference within the prescribed limits cannot be secured with a standard size replacement, or if the recess was damaged in removal of the original insert, the smallest oversize insert which can be installed with proper fit in the enlarged recess shall be specified by inspection personnel.

5-102. BACKLASHES. Backlash, or clearance, between mating gear teeth must be determined at reassembly.

5-103. PARTS TO BE MEASURED FOR WEAR. Features of parts indicated in Table X shall be measured at each overhaul. If no limit is placed on allowable increase or reduction in dimension, the measured value shall be recorded for comparison with the corresponding dimension of the mating part to determine serviceability of the fit, as defined in paragraph 5-100. All dimensions in this table are stated in inches.

TABLE X. PARTS TO BE MEASURED FOR WEAR

NAME OF PART	DESCRIPTION OF MEASUREMENT	REFER TO LIMIT NO. SECTION X	SPECIAL GAGE TOOL GROUP	DIMENSION NEW (INCHES) MINIMUM	MAXIMUM
CYLINDER ASSY Cylinder and Head:					
	Cylinder bore diameter (lower 3-3/8 inches)	1			
	Cylinder bore diameter at top of barrel	2,3			
	Cylinder bore out of round	4			
	Cylinder bore (reground) Apply Limit No. 5 to Limit No.	1,2,3			

TABLE X. PARTS TO BE MEASURED FOR WEAR (CONT)

NAME OF PART	DESCRIPTION OF MEASUREMENT	REFER TO LIMIT NO. SECTION X	SPECIAL GAGE TOOL GROUP	DIMENSION NEW (INCHES) MINIMUM	MAXIMUM
Valves	Seat widths	10,11	6		
	Seat angle	12	6		
	Intake stem diameter			0.433	0.434
	Intake guide bore		6	0.4352	0.4362
	Exhaust stem diameter			0.433	0.434
	Exhaust guide bore		6	0.437	0.438
	Intake length	21			
	Exhaust length	23			
	Face angle	19,20			
	Spring force	68 through 75			
Valve Rockers	Shaft bearing bore		4		
	Shaft diameter (Standard)			0.7177	0.7182
	Shaft diameter (Oversize)			0.7227	0.7237
	Bushing		6		
PISTON ASSY All Pistons	Pin bore diameter in piston		5	1.1250	1.1255
	Pin diameter			1.2[illegible]	1.1245
	Ring side clearance	27,28,29			
	Ring gap		8		
	Ring gap in barrel	30,31,32			
	Plug in pin (loose fitting type only)	33			
	Pin and plug assembly in barrel	36			
CONNECTING ROD ASSY	Piston pin bushing bore diameter		5		
	Bushing and bearing twist and convergence	42			
CRANKSHAFT ASSY	Main journal diameter	48,49			
	Crankpin diameter	47,50			
	Damper pin bushing diameter			0.624	0.626
	Damper pin diameter			0.5554	0.5574
	Run-out at center journals (shaft supported at front and rear journals)	51			
	End clearance of shaft in front main-thrust bearing (fully assembled)	46			
CAMSHAFT	Run-out at center journals (shaft supported at front and rear journals)	66			
	End clearance in assembled crankcase	65			
	Journal diameter			1.248	1.249
	Intake cam lobes (lift measured at center of width)			0.336	0.343

TABLE X. PARTS TO BE MEASURED FOR WEAR (CONT)

NAME OF PART	DESCRIPTION OF MEASUREMENT	REFER TO LIMIT NO SECTION X	SPECIAL GAGE TOOL GROUP	DIMENSION NEW (INCHES) MINIMUM	MAXIMUM
	Exhaust cam lobes (lift measured at center of width)			0.322	0.326
VALVE LIFTER	Body diameter	62		0.7177	0.7182
	Hydraulic unit leakdown		Use with appropriate master unit		
CRANKCASE	Valve lifter guide diameter	62	6		
	Camshaft bearings	64	2		
	Magneto gear supports	63		0.6845	0.6855
ACCESSORY CASE	Oil pump driver and driven gear bushing diameters			0.812	0.813
	Oil pump drive gear shaft diameter			0.8095	0.8105
	Oil pump driver and driven gear front shaft diameters	127		0.8095	0.8105
	Fuel pump idler gear bushing diameter	101		0.812	0.813
	Fuel pump idler gear shaft diameter			0.8095	0.8105
	Fuel pump drive gear bushing diameter	92		0.812	0.813
	Fuel pump drive gear shaft diameter			0.8095	0.8105
	Lower hydraulic pump drive front and rear bushing diameters			0.937	0.938
	Lower hydraulic pump drive gear front and rear shaft diameters			0.9345	0.9355
	Upper tachometer drive front and rear bushing diameters	94,109		0.812	0.813
	Upper tachometer drive gear front and rear shaft diameters			0.8095	0.8105
	Magneto cluster gear front bushing diameter	87		1.2495	1.2505
	Magneto cluster gear front shaft diameter			1.2465	1.2475
	Magneto adapter bushing diameter	77		1.7495	1.7505
	Magneto cluster gear shaft diameter			1.746	1.747
	Upper hydraulic pump drive front and rear bushing diameters	82,84		0.937	0.938
	Upper hydraulic pump drive gear front and rear shaft diameter			0.9345	0.9355
	Propeller governor drive front and rear bushing diameters	103,104		0.937	0.938

TABLE X. PARTS TO BE MEASURED FOR WEAR (CONT)

NAME OF PART	DESCRIPTION OF MEASUREMENT	REFER TO LIMIT NO SECTION X	SPECIAL GAGE TOOL GROUP	DIMENSION NEW (INCHES) MINIMUM	MAXIMUM
OIL PUMP	Propeller governor drive gear front and rear shaft diameter	124		0.9345	0.9355
	Generator adapter bushing diameter			1.1245	1.1255
	Generator drive gear shaft diameter			1.1215	1.1225
	Gear end clearance in pump body				
	Driver and driven gear shaft diameters			0.8095	0.8115
	Pump body bushing diameters			0.812	0.813

5–104. REPAINTING ENGINE PARTS.

5–105. If parts were stripped of enamel during the cleaning or repair process, or if enamel has been removed in spots, the bare metal of areas originally coated with either grey or black engine enamel must be protected by replacement of the coating. First, treat magnesium parts by chrome pickling in accordance with Specification MIL-M-3171. Apply two coats of primer conforming to Specification MIL-P-6889, Type I, to magnesium castings and one coat of the same material to aluminum and steel parts, except those subject to high operating temperatures. Finish cylinders with two coats of black heat resisting enamel (color No. 604), Specification MIL-E-5557, Type II. For all castings, etc., use grey enamel (color No. 513), Specification MIL-E-7729, Type II. Superior results will be obtained by spraying and applying the thinnest possible coating consistent with good coverage. Drips and runs shall be avoided. For baking instructions and temperatures, refer to Specification MIL-E-5557, amendment No. 3, paragraph 1–1 and to AN7729, paragraph 3–53.

CAUTION

Any primer or enamel accidentally applied to machined surfaces must be removed with the proper solvent. Scraping is not permissible. Machined surfaces must be protected by careful masking before spraying. This applies to all contacting surfaces, including studs and tapped holes.

Note

Mask a length of 1/4 inch at the curved end of each intake pipe (below the groove) before painting. Enamel on these areas interferes with installation of the tubes in cylinder ports. Do not paint cadmium plated pushrod housings.

5–106. PROTECTION OF REPAIRED PARTS FROM CORROSION.

5–107. Following repair or associated handling of engine parts, steel surfaces must be coated with fingerprint remover compound, Specification MIL-C-15074, to neutralize any acids deposited on the steel parts by fingerprints. After neutralizing acids, coat generously with corrosion-preventive compound, Specification MIL-C-6529, Type II, or a mixture composed of one part of Type I compound and three parts engine lubricating oil, Specification MIL-L-6082, grade 1100. This coating shall be applied to other metals if necessary under existing climatic conditions at the station. This instruction does not apply to piston rings, but piston pins must be protected.

CAUTION

Failure to neutralize acids deposited on steel parts by fingerprints will allow an etching action to go on under any protective coating and may roughen critical surfaces so as to adversely affect serviceability of parts.

SECTION VI

ASSEMBLY OF SUBASSEMBLIES

6–1. CLEANLINESS.

6–2. Parts of subassemblies must be assembled free of foreign matter to prevent scoring of bearings and sliding parts and contamination of the lubricating oil supply. Unless repaired parts and those awaiting assembly have been kept dust free, the corrosion preventive coating must be washed off with dry cleaning solvent, Federal Specification P-S-661, before assembly, and the parts inspected for residues of lapping compound, anti-seize compound, grit, dirty oil, and spots of paint on machined surfaces.

6–3. PROTECTION OF STEEL PARTS FROM CORROSION.

6–4. Before assembly, and after cleaning, coat all steel parts, bushings, and guides with a corrosion preventive mixture composed of one part corrosion preventive compound, Specification MIL-C-6529, Type I, mixed thoroughly with three parts engine lubricating oil, Specification MIL-L-6082, grade 1100. Keep compound in a closed container. Discard when it becomes diluted.

6–5. NEW SMALL PARTS REQUIRED.

6–6. Without further instructions, all parts of the following types shall be new parts drawn from stock: Lock wire, palnuts, lock washers, tab washers, cotter pins, copper-asbestos gaskets, rubber seal rings, soft gaskets, rubber hose connectors, and piston rings.

6–7. LOCK WIRE AND OTHER SAFETY DEVICES.

6–8. Applications of lock wire are obvious. All drilled head bolts must be lock wired in pairs. Twist lock wire and lead from one bolt to the next in such a manner as to tend to tighten both. All square, drilled head pipe plugs and hex head plugs shall be safetied by lock wire inserted through head holes, twisted and lead to the nearest accessible point of anchorage in such a direction as to tend to tighten the plug. (In some instances special clips and casting holes are provided for anchorage.) All slotted nuts shall be safetied by cotter pins, which must lie within the nut slots. Clip cotter pins to proper length, if necessary, so that the outer leg can be bent over the end of the stud or bolt and end at its center, while the inner leg is bent flat along side the nut, ending at the nut base. Screws with undrilled heads which are installed in blind holes are to be safetied with internal tooth lock washers installed under the heads. If the screw head is at an aluminum or magnesium metal surface, a plain washer of correct size must be installed between the soft metal and the internal tooth lock washer. Nut locks shall be run on stud ends after plain nuts are tightened to their correct torque values and shall be tightened by hand, then only 1/6- to 1/4-turn with a wrench. If a nut lock is removed for any reason it must not be reinstalled; use a new part.

6–9. TIGHTENING TORQUES.

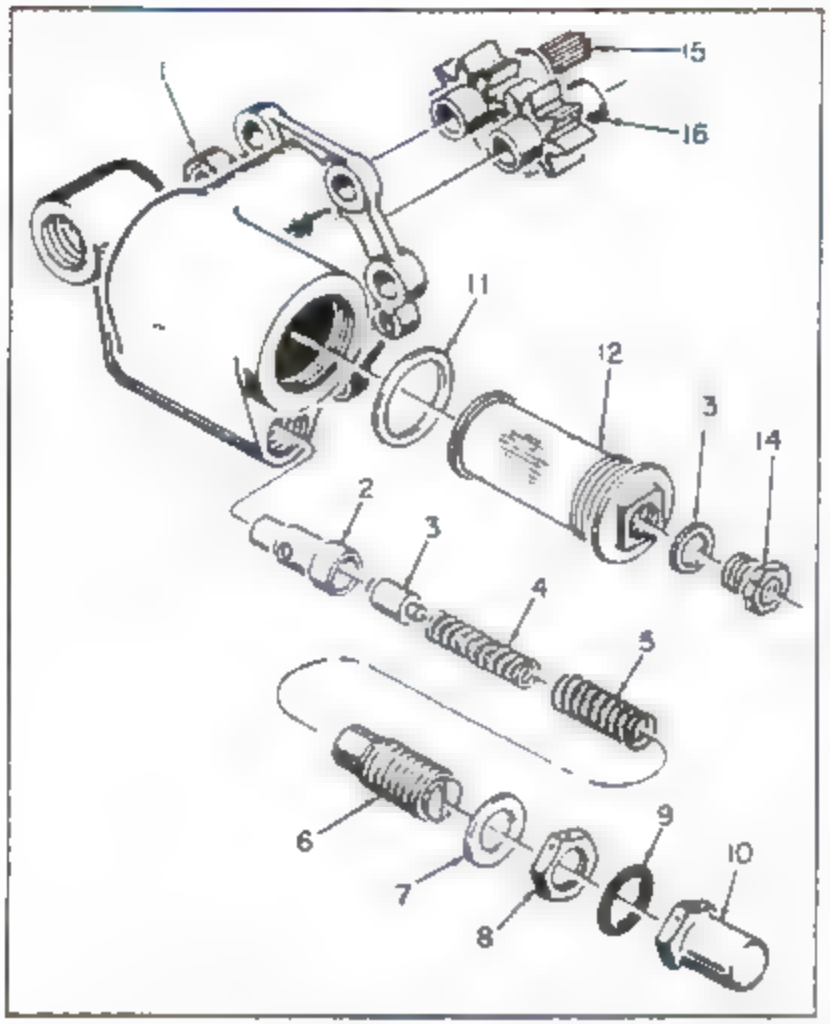
6–10. When no special torque is specified for tightening specific bolts, screws, and nuts the values specified in Section X for general use with the thread size in question will apply. Unless specifically noted, tightening torques specified in these instructions are intended for use without thread lubricant. Screws, bolts, and plain nuts shall be tightened to the single torque value specified. Slotted nuts shall be tightened to the low limit of the specified torque range and alignment of slot and stud hole inspected. If necessary, tighten further to align the nut slot, but do not exceed the specified high limit of torque. If a nut slot cannot be aligned with the bolt or stud hole within the specified torque limits, remove it and substitute another nut of the same part number. All plugs shall be tightened enough to be oil tight.

6–11. ACCESSORY CASE.

6–12. OIL PUMP. The pump parts to be assembled are illustrated in figure 6–1. Install parts in the ascending order of their index numbers. Refer to the legend accompanying figure 6–1 for details of assembly operations.

6–13. ACCESSORY CASE FRONT HALF AND GENERATOR DRIVE. Install parts in the case casting and assemble parts of the generator drive in the ascending order of their index numbers in figure 6–2. The legend provides detailed instructions. Figures 6–3 and 6–4 illustrate typical oil seal installation operations.

6–14. ACCESSORY CASE REAR HALF. In figure 6–5 the rear half casting (1) is illustrated as it lies on the work bench, ready for installation of parts and assemblies shown in exploded positions. Install these parts in the ascending order of their index numbers, using the compounds, tools and procedures described in the accompanying legend.

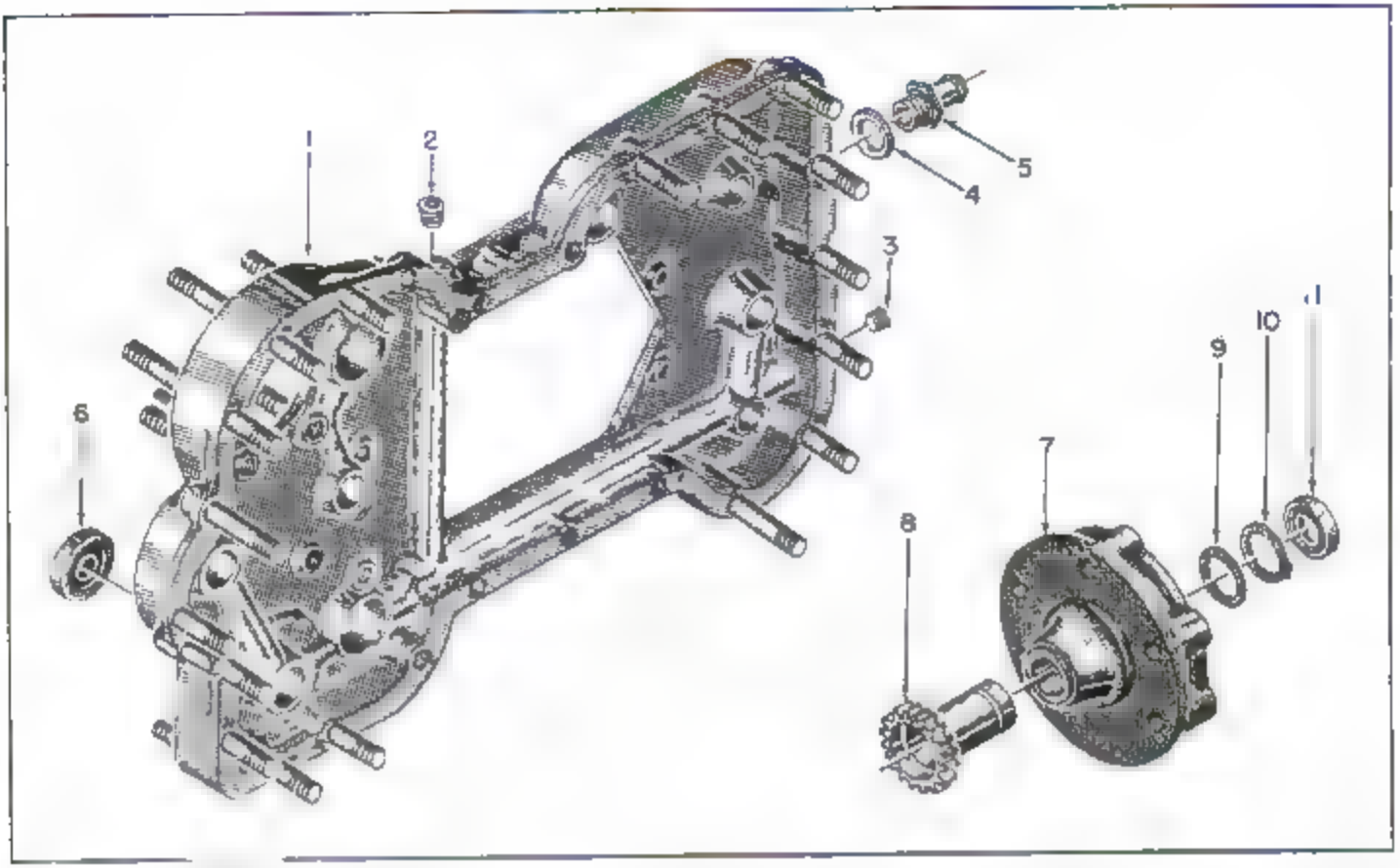


INDEX NO	PART NAME	APPLY COMPOUND	ASSEMBLY METHOD	TORQUE (IN LB)
1	Body and bushing assembly	none	None at this stage	none
2	Relief valve sleeve	*	Insert into guide	none
3	Relief valve plunger	*	Insert into sleeve	none
4	Relief valve inner spring	*	Insert into screw bushing	none
5	Relief valve outer spring	*	Insert into screw	none
6	Screw and bushing assembly	*	Screw half length into body	Nil
7	Copper-asbestos gasket	none	Place on screw	none
8	Lock nut	none	Tighten with 1-3 8 inch wrench	90
9	Copper-asbestos gasket	none	Place on screw	none
10	Relief valve cap	none	Tighten with 1-3 8 inch wrench	70
11	Copper-asbestos gasket	none	Place on screen against flange	none
12	Pressure oil screen assemble	†(thread)	Tighten with 1 inch open end wrench	200
13	Copper-asbestos gasket	none	Place on plug	none
14	Hex drilled head plug	†	Tighten with 7/8 inch wrench	60
15	Oil pump driver gear	*	Insert in body bushing carefully	none
16	Oil pump driven gear	*	Mesh with driver and insert carefully	none

* Mixture of one part corrosion preventive compound, Specification MIL-C-6529, Type I, and three parts aircraft engine lubricating oil, Specification MIL-L-6082, grade 1100.

† Anti-seize compound, Specification MIL-T-5544. Apply only a film.

Figure 6–1. Oil Pump Subassembly Procedure



INDEX NO	PART NAME	APPLY COMPOUND	ASSEMBLY METHOD	TORQUE (IN LB)
1	Front half casting with bushings and studs	none	None at this stage	none
2	Socket head pipe plug	†	Tighten with 1/4 inch Allen wrench	oil tight
3	Socket head pipe plug	†	Tighten with 1/4 inch Allen wrench	oil tight
4	Copper-asbestos gasket	none	Place on hose nipple thread	none
5	Hose nipple	†	Tighten with 1-inch box end wrench	oil tight
6	Upper hydraulic pump drive oil seal	*	Press in with arbor press and drift, seal lip inward	none
*	Generator adapter assembly	none	None at this stage	none
8	Generator drive gear assembly	*	Insert through adapter bushing	none
9	Aluminum thrust washer	*	Place in recess around shaft end	none
10	Truarc snap ring	none	Spread with Truarc pliers and release in shaft groove; then measure gear end clearance	none
1	Generator drive oil seal	*	Press in recess around shaft end, seal lip inward. Use arbor press and drift	none

* Mixture of one part corrosion preventive compound, Specification MIL-C-6529, Type I, and three parts aircraft engine lubricating oil, Specification MIL-L-6082, grade 1100.

† Anti-seize compound, Specification MIL-T-5544. Apply only a film.

Figure 6–2. Accessory Case Front Half and Generator Drive Subassembly Procedure

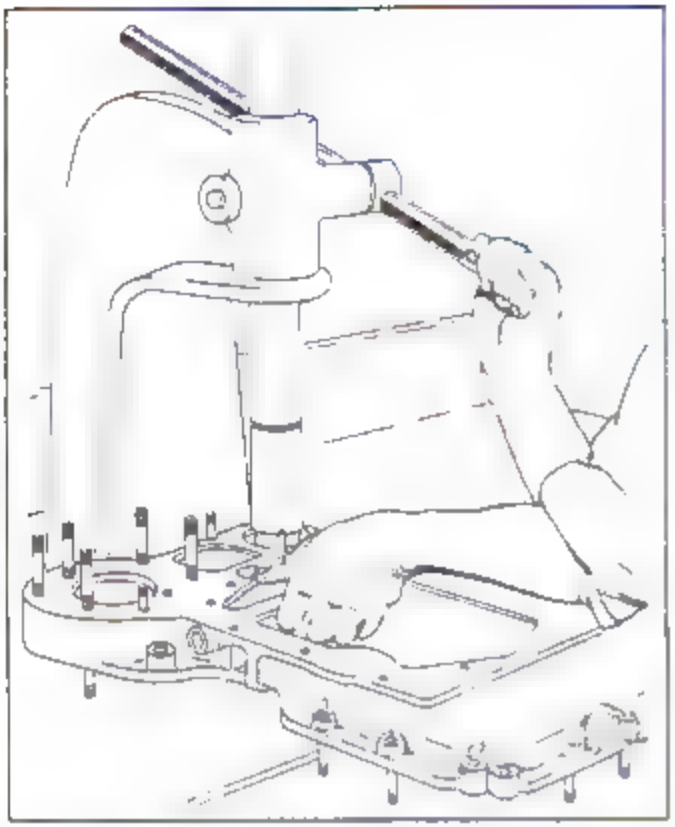


Figure 6–3 Installing Upper Hydraulic Pump Drive Oil Seal

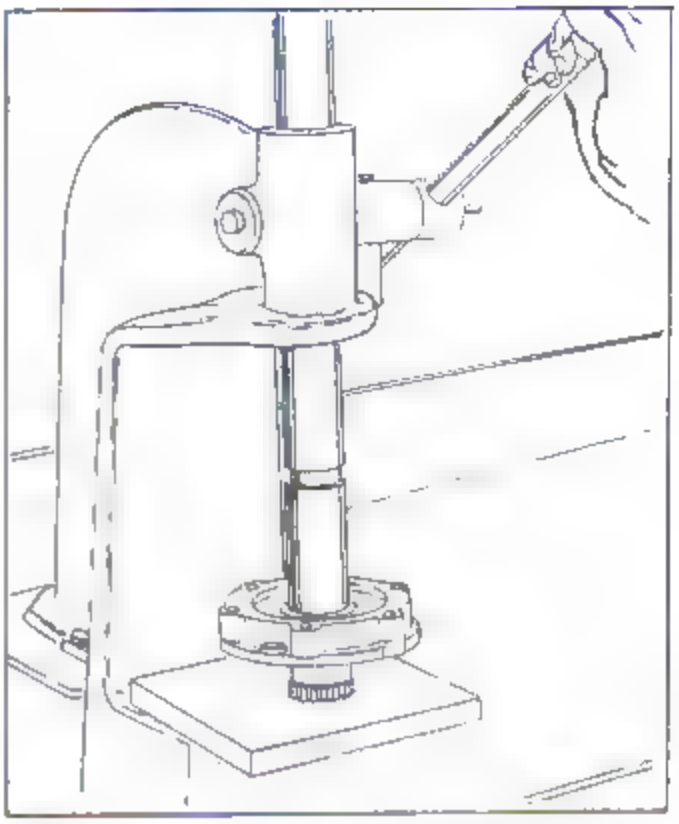


Figure 6–4. Installing Generator Drive Oil Seal

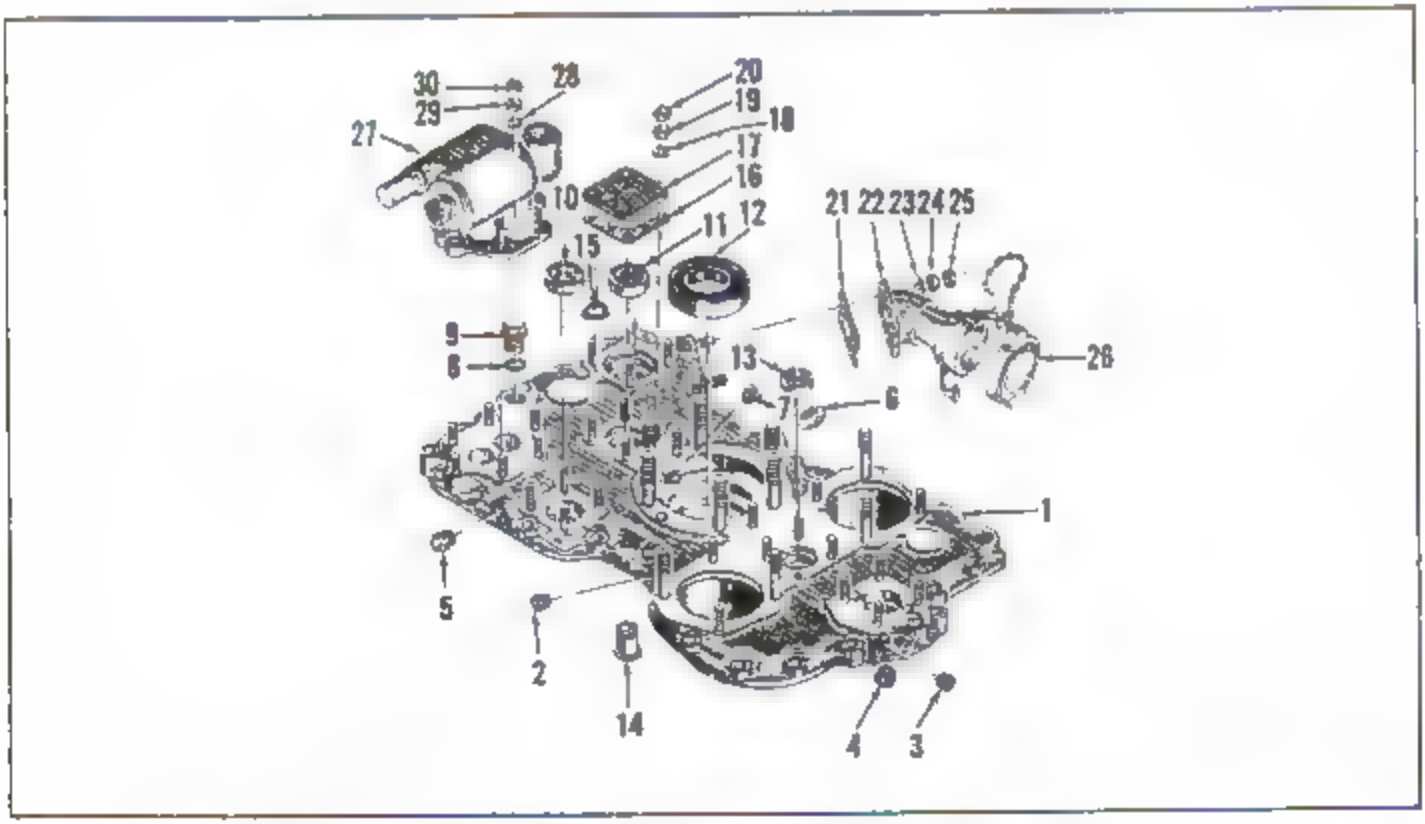


Figure 6–5 Accessory Case Rear Half Subassembly Procedure (Sheet 1 of 2)

INDEX NO	PART NAME	APPLY COMPOUND	ASSEMBLY METHOD	TORQUE (IN LB)
1	Rear half casting with bushings and studs	none	None	none
2	Socket head pipe plug	†	Tighten with 3/16 inch Allen wrench	not specified
3	Socket head pipe plug	†	Tighten with 3/16 inch Allen wrench	not specified
4	Square head pipe plug	†	Tighten with 7/16 inch open end wrench	not specified
5	Square head pipe plug	†	Tighten with 7/16 inch open end wrench	not specified
6	Square head pipe plug to suit tapped hole	†	Tighten with 9/16 or 7/16 inch open end wrench	not specified
7	Socket head pipe plug	†	Tighten with 9/16 inch open end wrench	not specified
8	Copper-asbestos gasket	none	Place on plug 9	none
9	Special hex head plug	†	Screw into oil pump pad and tighten	not specified
10	Lower hydraulic pump drive oil seal	*	Press in with arbor press and drift	none
11	Fuel pump drive oil seal	*	Press in with arbor press and drift	none
12	Starter jaw oil seal	*	Press in with arbor press and drift	none
13	Upper tachometer drive oil seal	*	Press in with arbor press and drift	none
14	Lower tachometer drive oil plug	none	Insert into bushing from front side	none
15	Truarc snap ring	none	Spread with Truarc pliers. Release in plug groove	none
16	Gasket	‡	Place on lower tachometer drive pad	none
17	Vacuum pump adapter cover	none	Place on lower tachometer drive gasket	none
	ATTACHING PARTS			
18	Plain washer	none	Place on four studs	none
19	Plain nut	none	Tighten with 7/16 inch wrench	75
20	Nut lock	none	Tighten only 1/6 turn with wrench	Nil
21	Oil filler spout gasket	‡	Place on case pad	none
22	Oil filler spout assembly	none	Place on gasket	none
	ATTACHING PARTS			
23	Plain washer	none	Place on two studs	none
24	Plain nut	none	Tighten with 7/16 inch wrench	75
25	Nut lock	none	Tighten only 1/6 turn with wrench	Nil
26	Oil filler cap retainer assembly	none	Turn by hand to lock. Snap ring on filler neck	Nil
27	Oil pump assembly	*(gears)	Insert gear shafts in case bushings. Seat body flange	none
	ATTACHING PARTS			
28	Plain washer	none	Place on six studs	none
29	Plain nut	none	Tighten with 1/2 inch wrench. Insert drive gear and test for free rotation of pump gears	200
30	Nut lock	none	Tighten only 1/6 turn with wrench	Nil

* Mixture of one part corrosion preventive compound, Specification MIL-C-6529, Type I, and three parts aircraft engine lubricating oil, Specification MIL-L-6082, grade 1100.

† Anti-seize compound, Specification MIL-T-5544.

‡ Gasoline and oil resistant grease, Specification MIL-L-6032. Apply thin film and work into gasket material, leaving no excess to plug oil passages.

Figure 6-5 Accessory Case Rear Half Subassembly Procedure (Sheet 2 of 2)

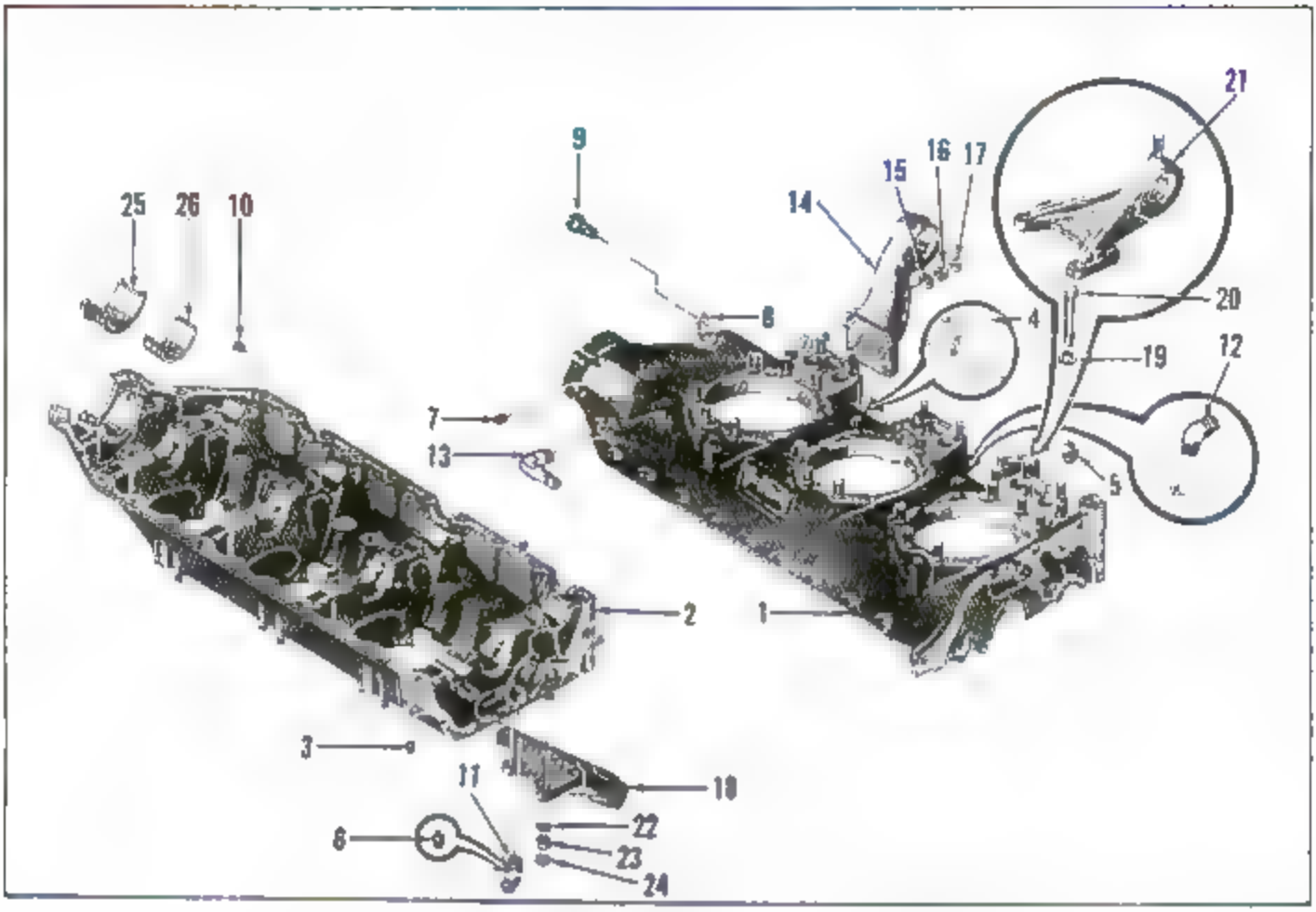


Figure 6–6. Crankcase Subassembly Procedure (Sheet 1 of 2)

6–15. CRANKCASE HALVES.

6–16. The crankcase castings and the parts to be installed in them are illustrated in exploded positions in figure 6–6. Install the appropriate parts in the ascending order of their index numbers in figure 6–6, observing the procedure details given in the legend which accompanies the figure. If the engine is to be tested immediately after assembly, a tube connector may be installed in lieu of the plug (3, figure 6–6) for an oil pressure gage line

CAUTION

Casting mount pads, flanges of attached brackets, bearing seats and bearing inserts must be dry and free of oil and other foreign matter before parts are installed. Before installing main bearing inserts, check part numbers on their backs. Undersize parts are designated by the dash number "U10" following the basic part number. These are to be used only when the crankshaft has been regound to 0.010 inch undersize. All intermediate and rear main bearing inserts shall be new parts.

6–17. OIL SUMP.

6–18. Place a copper-asbestos gasket on the drain plug, and screw the plug into the oblique drain boss at the lower rear edge of the sump. Tighten the plug, but do not install lock wire. Coat the thread of the oil suction screen assembly with anti-seize compound, Specification MIL-T-5544, and screw the elbow shaped assembly into the rear boss of the sump. Tighten the screen assembly oil tight and until the straight tube points obliquely upward and to the right at an angle of approximately 30 degrees to the vertical. Slide a 1-inch ID x 4-inch rubber hose connector over the screen assembly tube as far as possible, and place two hose clamps on it. Tighten the clamps only snug to prevent loss. Attach the front support bracket loosely to the tapped insert in the top horizontal surface at the front side of the sump with a drilled hex head bolt and with a plain steel washer under its head. Place an oil resistant "O" ring seal in the groove around the sump top inlet tube. Push a 2-inch ID x 2-1/2 inch rubber hose connector over the sump front inlet tube as far as it will go, and place on it two hose clamps. Tighten the clamps only snug to prevent loss. Do not install the oil gage rod.

INDEX NO	PART NAME	APPLY COMPOUND	ASSEMBLY METHOD	TORQUE (IN LB)
1	Crankcase 1, 3, 5 side with studs	none	None at this stage	none
2	Crankcase 2, 4, 6 side with studs	none	None at this stage	none
3	Square head pipe plug	‡	Tighten with 9/32 inch open end wrench	oil tight
4	Square head pipe plug	‡	Tighten with 9/32 inch open end wrench	oil tight
5	Square head pipe plug	‡	Tighten with 9/16 inch open end wrench	oil tight
6	Pipe plug	‡	Tighten with 9/16 inch open end wrench	oil tight
7	Socket head pipe plug	‡	Tighten with 3/16 inch Allen wrench	oil tight
8	Gasket	none	Place on oil gallery plug	none
9	Oil gallery hose adapter	†	Install in 1, 3, 5 side only Tighten with 1 inch hex wrench. Install 3/8 inch pipe plug in adapter hole	oil tight
10	Oil gallery plug	‡	Tighten in end of oil gallery	oil tight
11	Flared tube to pipe elbow	‡	Tighten with 7/8 inch open end wrench	oil tight
12	Flared tube to pipe elbow	‡	Tighten with 7/8 inch open end wrench	oil tight
13	Pipe thread to hose elbow	‡	Tighten with 15/16 inch open end wrench	oil tight
14	Front, 1, 3, 5 side mount bracket	none	Place on 1, 3, 5 side case pad	none
	Front, 2, 4, 6 side mount bracket	none	Place on 2, 4, 6 side case pad	none
	ATTACHING PARTS			
15	Plain steel washer	none	Place on eight case studs	none
16	Plain nut	none	Tighten on eight case studs	300
17	Nut lock	none	Tighten eight only 1/6 turn with wrench	Nil
18	Rear 2, 4, 6 side engine rear mount bracket	none	Place on studded case pad	none
19	Plain steel washer	none	Place on bolt (20)	none
20	Hex head bolt	none	Insert in short through bolt hole before attaching rear bracket	none
21	1, 3, 5 side rear mount bracket	none	Place on studded case pad	none
	ATTACHING PARTS			
22	Plain steel washer	none	Place on four studs	none
23	Plain nut	none	Tighten with 1/2 inch hex wrench	200
24	Nut lock	none	Tighten only 1/6 turn with wrench	Nil
25	Crankshaft main-thrust bearing insert	none	Insert into front bearing seat of each half	none
26	Intermediate and rear main bearing insert	none	Insert into four seats of each half	none

† Anti-seize compound, Specification MIL-T-5544. Apply only a film.

‡ Gasoline and oil resistant grease, Specification MIL-L-6032 Apply thin film, and work into gasket surfaces, leaving no excess to plug oil passages.

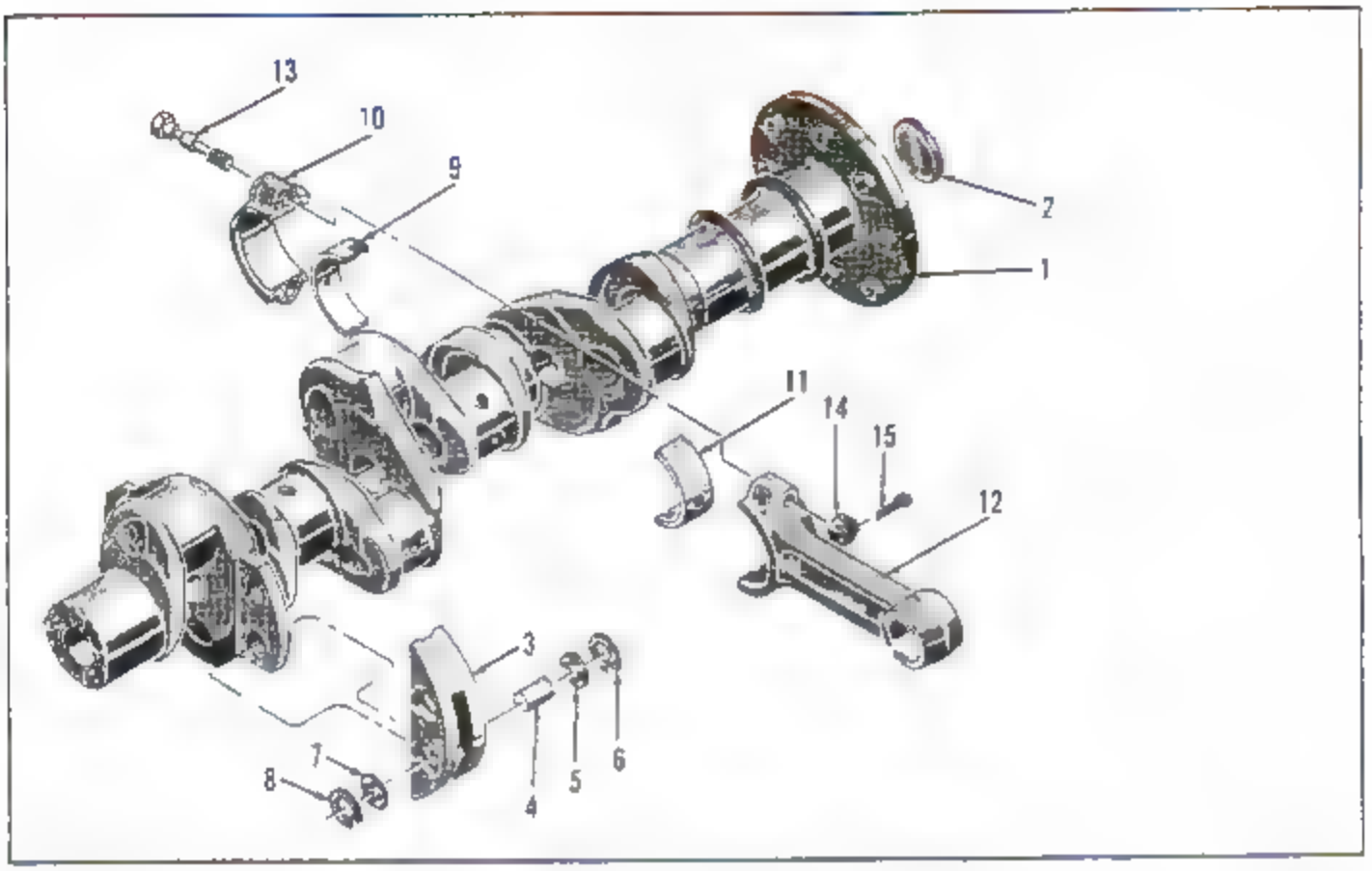
Figure 6–6. Crankcase Subassembly Procedure (Sheet 2 of 2)

6–19. HYDRAULIC VALVE LIFTERS.

6–20. Clean all parts in dry cleaning solvent, Federal Specification P-S-661, immediately before beginning assembly. Dry the parts with dry compressed air, and coat internal parts with the corrosion preventive oil mixture. Do not allow an excess of oil in the hydraulic unit cylinder or inside the bodies. Start the plunger into the cylinder and twist it, while pushing inward to wind up the spring so that it will snap into the cylinder counterbore. Place the unit in the tapper body, and lay the pushrod socket on the piston head, flat face inward. Use a discarded pushrod or similar instrument to compress the plunger spring while the snap ring is installed. When all litters have been assembled in this manner, they must be covered to protect from dust and grit until they are installed.

6–21. CRANKSHAFT AND CONNECTING RODS.

6–22. The crankshaft assembly is illustrated in figure 6–7, with detail parts shown in exploded positions. The Group 3 crankshaft assembly holder must be modified to accommodate the flange type crankshaft. One of its stands is equipped with a plug to fit the 1.44-inch diameter hole in splined type crankshaft rear end. A larger plug must be substituted to fit the 1.88-inch diameter hole in the flanged shaft propeller hub and this type of shaft supported in a reversed direction in the two stands of the tool. Detail parts are installed in the numerical order of their index numbers in figure 6–7. Refer to the legend accompanying that figure for details of assembly methods, lubricants and tightening torques to be used.



INDEX NO.	PART NAME	APPLY COMPOUND	ASSEMBLY METHOD	TORQUE (IN LB)
1	Flanged crankshaft	*	Clamp in Group 3 crankshaft assembly holder	none
2	Hubbard plug	none	Tap into place with fibre drift and hammer. Tap once firmly to expand tight	none
3	Crankshaft damper counterweight	*	Place two, in turn, in original positions	none
	ATTACHING PARTS			
4	Counterweight retaining pin	*	Place two in bushings of each counterweight	none
5	Pin retaining plate	*	Place one in each front counterweight recess	none
6	Truarc internal snap ring	none	Compress with Truarc pliers and release in grooves to retain four plates	none
7	Pin retaining plate	*	Place one in each rear counterweight recess	none
8	Truarc internal snap ring	none	Compress with Truarc pliers No. 1 or 21 and release in grooves to retain four plates	none
9	Crankpin bearing insert	*	Press six into bearing caps with tangs in notches	none
10	Connecting rod bearing cap	none	Place cap and insert on crankpin with numbered bolt boss on top (cap in horizontal working position)	none
11	Crankpin bearing insert	*	Press six into connecting rods with tangs in notches	none

Figure 6–7. Crankshaft and Connecting Rod Subassembly Procedure (Sheet 1 of 2)

INDEX NO	PART NAME	APPLY COMPOUND	ASSEMBLY METHOD	TORQUE (IN LB)
12	Connecting rod with bushing	none	Place each of six, in turn, on crankpins for cylinders as numbered on rod upper bolt bosses. Match rod and cap numbers	none
	ATTACHING PARTS			
13	Connecting rod bolt	†	Insert through cap and rod bosses	none
14	Hex slotted nut	none	Tighten with 1/2 inch hex wrench	340-360
15	Cotter pin	none	Insert one through each of 12 bolts. Bend one leg down. Bend other leg up and cut off flush with bolt end	none

* Corrosion preventive compound, Specification MIL-C-6529, Type II, or mixture of one part Type I compound and three parts aircraft engine lubricating oil, Specification MIL-L-6082, grade 1100

† Anti-seize compound, Specification MIL-T-5544. Apply only a film

Figure 6–7 Crankshaft and Connecting Rod Subassembly Procedure (Sheet 2 of 2)

CAUTION

Before installing bearing inserts, inspect part numbers stamped on their backs. If the basic part number is followed by the dash number "-10", the insert is to be installed only with a 0.010 undersize reground crankshaft, identified by the symbol ".010" acid etched on the front face of the propeller mount flange or front thrust flange. Crankshaft damper counterweights must be installed in their original positions. Reversing them or interchanging them between sides of the shaft or between crankshafts may produce an unbalanced assembly and cause destructive engine vibration. When rods and caps are assembled, hold each rod in working position (left or right according to cylinder number), and make sure that rod and cap cylinder numbers are matched, on top and in agreement with the number of the cylinder which the rod will enter. (Refer to figure 1–3 for cylinder arrangement.)

6–23 INTAKE TUBES

6–24. Place the loose aluminum flanges on the curved ends of the intake tubes, with flange recesses facing tube ends. Push a new (white rubber) seal ring over the end of each tube and into the seal groove. Slide the flanges up over the seals. Push a new rubber hose connector on the straight end of each tube in approximately working position, and place two hose clamps on each hose. Tighten the clamps only snug to prevent loss.

6–25 PISTONS.

6–26. Install piston rings and pins in the ascending order of their index numbers in figure 6–8. Keep pins with original mating pistons unless new parts are to be installed. Use only new piston rings. Before inserting pins, measure ring side clearances, as described in paragraph 5–50. Lubricate only inserted ends of pins. Stamp position numbers on new pistons in same locations as on discarded parts (top surface rim). Stamp lightly.

CAUTION

Four types of piston pin assemblies have been produced. The first had loose aluminum end plugs. The second had similar plugs pressed in the pin. These plugs may be identified by large fillets at the pin ends. The assemblies are of same weight and interchangeable. The third type pin assembly has a solid aluminum plug extending through and beyond the pin ends, where it is held by four staked indentations. The current type assembly also has a solid plug, but it is hot forged to conical shape beyond the pin ends. The latter two types are heavier than the first two, the fourth type being heaviest of all; therefore, only the first two types and the last two may be mixed in any engine assembly without risk of exceeding the specified maximum of 1/2 ounce difference in piston weight. In order to avoid unduly rough operation resulting from dynamic unbalance, it is recommended that piston assemblies, as well as pistons, be checked for uniform weight within 1/2 ounce if pin assemblies are not of the same type throughout. Ascertain that marked piston part numbers are correct to suit engine model. Refer to paragraph 5–50 for application of oversize rings. Oversizes are identified by dash numbers following basic part numbers. Piston weights, in any engine set, shall not vary more than 1/2 ounce from lightest to heaviest.

INDEX NO.	PART NAME	APPLY COMPOUND	ASSEMBLY METHOD
1	Piston	none	None at this stage
2	Oil control piston ring	none	Spread and lower over piston top. Release in third groove, part No. up
3	Plain compression ring	none	Spread and lower over piston top. Release in second groove, part No. up
4	Chrome faced compression ring	none	Spread and lower over piston top. Release in top groove, part No. up
5	Piston pin and plug assembly	§	Push partially into piston hole. Leave recess for rod clear

§ Sun-O-Co Way Oil or similar light mineral lubricating oil

Figure 6-8. Piston Subassembly Procedure

6–27. CYLINDERS

6–28 Assemble in the ascending order of their index numbers, parts illustrated in exploded positions in figure 6–9 Consult the legend which accompanies that figure for procedures, tools and lubricants to be used Install piston subassemblies in cylinders, preparatory to final assembly, as follows:

a Lay completed cylinder subassemblies on the work bench in the numerical order of their position numbers (stamped on edges of base flanges) with pushrod housings on top

b. Place piston subassemblies with corresponding numbered cylinders Remove piston pins, keeping them with mating pistons

c To cylinder bores, piston walls, and rings apply a copious coating of Sun-O-Co Way Oil or castor oil, Federal Specification JJJ-C-86

d. Place all top ring and oil control ring gaps at right angles to the pin holes and so that they will be on top when the piston position numbers are forward. Place second compression ring gaps opposite

e. Starting with No. 1, compress piston rings with a clamp made of sheet steel, and push each piston, in turn, into its cylinder until rings are in the bores and pin holes outside. Install pistons in inverted positions, since cylinders are inverted.

f. Dip piston pin assemblies in the same type of oil specified in step c. Insert each in the proper piston bore far enough to hold but clear of the rod recess. Pins should extend to the installer's left in this inverted position

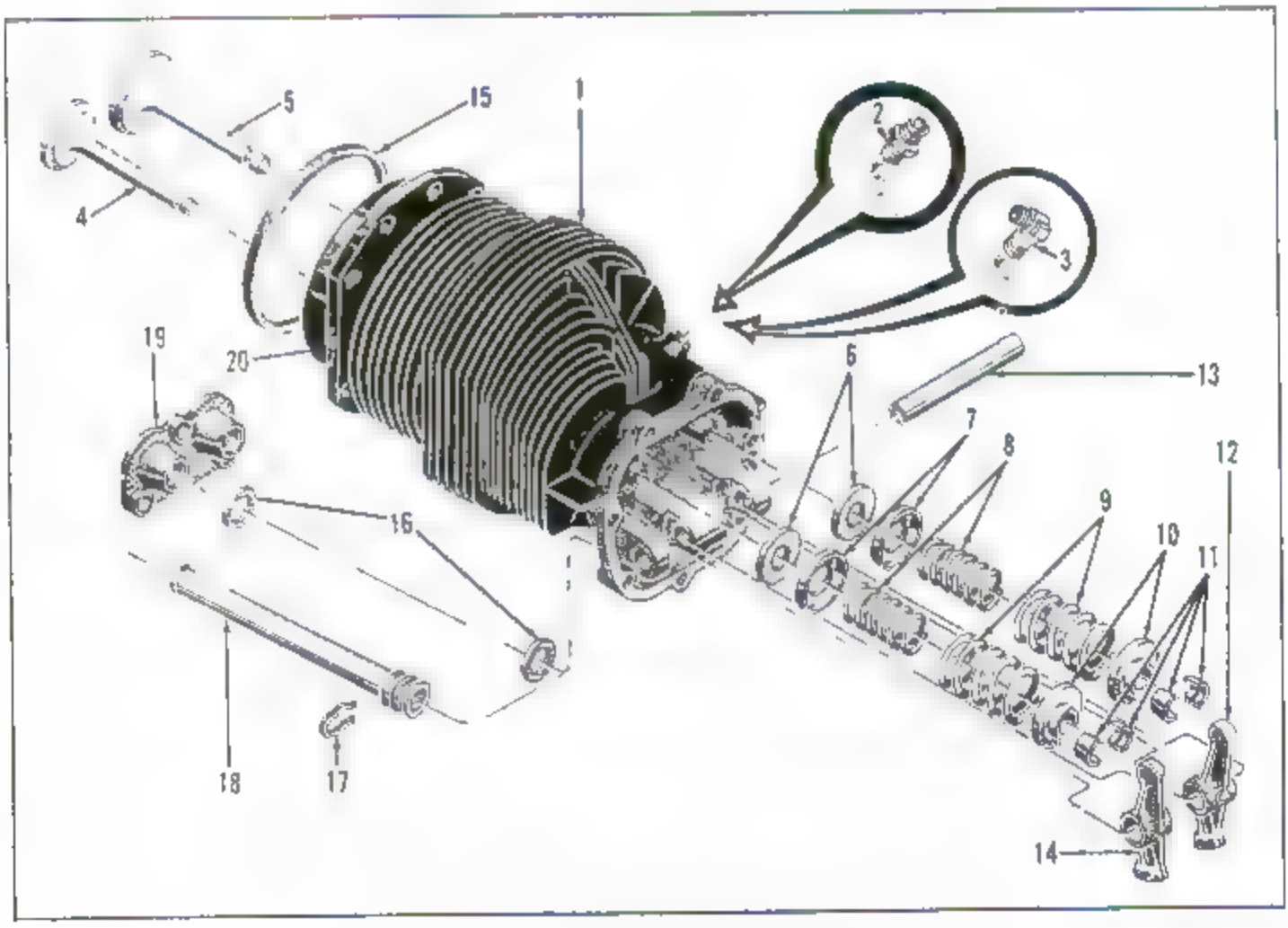


Figure 6–9 Cylinder Subassembly Procedure (Sheet 1 of 2)

INDEX NO.	PART NAME	APPLY COMPOUND	ASSEMBLY METHOD
1	Cylinder and head assembly	§ (bore)	None at this stage (Refer to para 6-28.)
2	Priming jet nipple cylinders 1, 3, 4, 6	†	Tighten with box end wrench
3	Priming jet elbow cylinders 2, 5		
4	Exhaust valve	§	Insert in guide carefully
5	Intake valve	§	Insert in guide carefully
6	Valve spring spacers old type springs	§	Place over two valve guides with role chamfers toward
7	Valve spring inner retainers	§	Place over two valve guides — cups out
8	Inner valve springs	§	Place over two valve guides
9	Outer valve springs	§	Place over two inner springs
10	Valve spring outer retainers	§	Place on two sets of springs
11	Valve stem keys	§	Support cylinder on valve heads in Group 4 cylinder and valve holding fixture. Secure flange with fixture clamps. Push rocker shaft through supports. Compress valve springs with tool shown in figure 4-3. Insert keys. Release springs slowly. See that keys seat in valve stem grooves. Remove shaft
12	Intake valve rocker	§	Place between supports of original cylinder
13	Valve rocker shaft	§	Insert through intake valve rocker
14	Exhaust valve rocker	§	Place between supports of original cylinder. Push shaft through rocker and last support
15	Cylinder base packing (rubber ring)	none	Place on cylinder skirt, against flange, without twist
16	Pushrod housing packing (rubber ring)	§	Place on ends of non-removable housing, or on open end and inside opposite end flange of removable housing
17	Pushrod housing retainer	none	Snap one into space between beads of each removable pushrod housing
18	Removable pushrod housing	none	Push packing into cylinder head hole until retainer touches. Install two per cylinder
19	Pushrod housing flange	none	Push fully over exposed ends of two housings. Use appropriate type to suit housings
20	Cylinder oversize marking "-15"		

§ Sun-O-Co Way Oil or similar light mineral lubricating oil. (Fill pushrods by immersing in pan of oil in slightly inclined position).

† Anti-Seize compound, Specification MIL-T-5544. Apply only a film

Figure 6-9. Cylinder Subassembly Procedure (Sheet 2 of 2)

SECTION VII

FINAL ASSEMBLY

7–1. GENERAL INSTRUCTIONS

7–2. CLEANLINESS. Subassemblies and separate engine parts awaiting final assembly must be protected from dirt. Assembly should be accomplished, as nearly as possible, without admission of abrasives and matter which may plug oil passages. Partial assemblies must be kept covered when not in the process of completion. Individual parts shall be washed in approved solvent to remove gritty corrosion preventive, when necessary, and washing shall be followed by drying with dry compressed air. Subassemblies cannot be washed without possible removal of corrosion preventive from internal parts, and such cleaning shall not be attempted, hence it is particularly important to protect them until they are installed.

7–3. CORROSION PREVENTIVE. Instructions of paragraph 6–4 shall be carried out during operations described in this section, where they are applicable.

7–4. SMALL PARTS. Parts of the types listed in paragraph 6–6 required for work described in this section shall be new parts.

7–5. SAFETY DEVICES. Instructions in paragraph 6–8 shall be followed during final assembly operations.

7–6. TIGHTENING TORQUES. Tightening torques specified in Section X for specific attachments shall be observed during final assembly work. In all other instances, the instructions in paragraph 6–10 shall be followed. Apply specified torques in the following manner:

a. Use the proper size torque-indicating wrench for the torque to be applied. Use standard nut sockets and extension bars, as required by the nut or bolt position.

b. Tighten slotted nuts to minimum specified torque.

c. If nut slot and cotter pin hole do not align, continue to tighten until either alignment is achieved or maximum specified torque reached, whichever occurs first.

d. If nut slot and cotter pin hole cannot be aligned within torque limits, remove the nut and substitute another of the same part number. Do not use torque-indicating wrenches to loosen attaching parts.

e. Always apply tightening torque evenly. Do not jerk the tool.

f. Do not back up a nut to align cotter pin hole and slot.

g. Keep socket extension, or special wrench, straight in line with the bolt or stud. This is particularly important when using Group 4 cylinder base nut wrench to avoid breakage.

7–7. PREPARATION OF ENGINE STAND

7–8. Ascertain that the assembly stand is equipped with the proper type of adapters to fit the four engine mount brackets of the engine model to be assembled. Turn the rotatable engine bed to the position required to permit attachment of the crankcase 2, 4, 6 side subassembly with its parting flange upward. Lock the bed in this position, and apply brakes to prevent movement of the stand. Obtain a 2x4 inch wood brace or other suitable support to hold up the crankcase 2, 4, 6 side during early stages of assembly.

7–9. ASSEMBLY OF CRANKCASE

7–10. Assemble the crankcase subassemblies and related parts illustrated in exploded positions in figure 7–1 in the ascending order of their index numbers. Refer to the legend accompanying that figure for application of parts to each model, identification of parts, tools, and compounds to be employed, and for details of assembly techniques. In addition, apply the following instructions at appropriate stages of the procedure.

a. Before installing the crankshaft, spread a film of gasoline and oil resistant grease, Specification MIL-G-6032, on surfaces of the crankshaft oil seal recess in each case casting. Do not apply an excessive quantity of grease, since any excess which is squeezed into the case may plug oil passages.

b. After installation of valve lifters, crankshaft, and camshaft, place a length of grade A, No. 50 silk thread along the upper and lower parting flanges of the 2, 4, 6 side of the crankcase. Apply a minimum quantity of gasoline and oil resistant grease to hold the thread in position. After all flange attaching bolt nuts have been tightened, cut ends of the thread off where they emerge from the case.

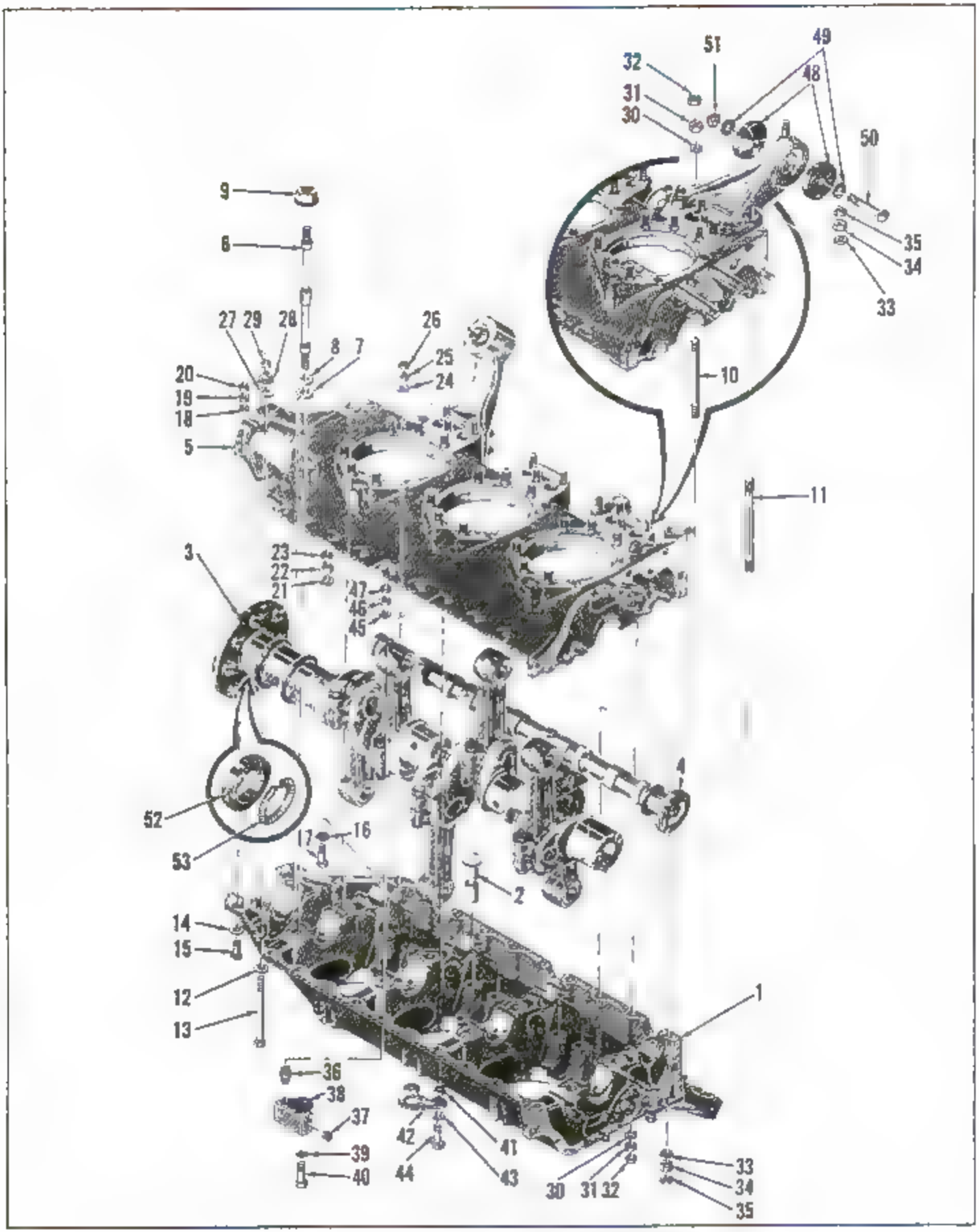


Figure 7–1. Crankcase Assembly Procedure (Sheet 1 of 3)

INDEX NO	PART NAME	APPLY COMPOUND	ASSEMBLY METHOD	TORQUE (IN LB)
1	Crankcase 2, 4, 6 side subassembly	See para 7–9.	Attach mount brackets to stand adapters. Place support under casting to hold in illustrated position.	none
2	Hydraulic valve lifter assembly (Install steel faced lifters with cast iron camshaft or cast iron faced lifters with forged steel camshaft.)	•	Insert in all guides, both halves. Loop a rubber band around each pair in 1, 3, 5 side, through cylinder opening and around studs to retain lifters during assembly of case	none
3	Flanged crankshaft and connecting rods	•	Lay in 2, 4, 6 side bearings. Measure end clearance	none
4	Camshaft	•	Lay in 2, 4, 6 side bearings. Measure end clearance	none
5	Crankcase 1, 3, 5 side subassembly (Note: Install protectors on all cylinder pads to limit connecting rod side movement.)	See para 7–9	Place Nos. 1, 3 and 5 connecting rods upright. Hold case in illustrated position, and lay it on the 2, 4, 6 side. Remove retainers from upper valve lifters.	none
6	Through bolt	•	Tap through 8 holes adjacent to crankshaft bearings	none
7	Plain steel washer	none	Place on four through bolt ends not in cylinder pads	none
8	Steel spacer	none	Place on four washers	none
9	Flanged nut	none	Run on through bolts over four spacers	Nil
10	Through bolt		Tap through one case hole	none
11	Through bolt		Tap through one case hole	none
12	Plain steel washer	none	Place on two case hole bolts (13)	none
13	Hex head bolt	none	Insert through two case holes	none
14	Plain steel washer	none	Place on eleven upper flange bolts	none
15	Hex head bolt	none	Insert through eleven upper flange holes	none
16	Plain steel washer	none	Place on seven lower flange bolts	none
17	Special bolt	none	Insert through seven lower flange holes	none
18	Plain steel washer	none	Place on eleven upper flange bolts	none
19	Plain nut	none	Tighten eleven with 7/16 inch socket wrench	65
20	Nut lock	none	Tighten eleven only 1/6 turn with wrench	Nil
21	Plain steel washer	none	Place on one upper flange bolt	none
22	Plain nut	none	Tighten one with 7/16 inch socket wrench	75
23	Nut lock	none	Tighten one only 1/6 turn with wrench	Nil
24	Plain steel washer	none	Place on seven lower flange bolts (17)	none
25	Plain nut	none	Tighten seven with 1/2 inch socket wrench	200
26	Nut lock	none	Tighten seven only 1/6 turn with wrench	Nil
27	Plain steel washer	none	Place on two case hole bolts (13)	none
28	Flanged hex nut	none	Tighten with 9/16 inch socket wrench	330
29	Nut lock	none	Tighten two only 1/6 turn with wrench	Nil
30	Plain steel washer	none	Place on short 5/16 inch through bolt	none
31	Plain nut	none	Tighten with 1/2 inch socket wrench	200
32	Nut lock	none	Tighten only 1/6 turn with wrench	Nil
33	Plain steel washer	none	Place on two through bolts	none
34	Plain nut	none	Tighten two with 9/16 inch socket wrench	370-390
35	Nut lock	none	Tighten two only 1/6 turn with wrench	Nil
36	Nipple	†	Tighten six with 7/16 inch hex wrench	tight
37	Pipe plug	†	Tighten in distributor rear hole	moderate
38	Primer distributor	none	Place on sixth hole from rear of flange	none
	ATTACHING PARTS			
39	Plain steel washer	none	Place on distributor attaching bolt	none
40	Bolt. Also see 21, 22, 23	none	Insert through distributor and case flange	none

Figure 7–1. Crankcase Assembly Procedure (Sheet 2 of 3)

INDEX NO.	PART NAME	APPLY COMPOUND	ASSEMBLY METHOD	TORQUE (IN LB)
41	Plain steel washers	none	Place two on lifting eye	none
42	Engine Lifting eye	none	Place over fourth and fifth holes from rear, upper flange	none
	ATTACHING PARTS			
43	Plain steel washers	none	Place two on lifting eye bolts	none
44	Hex head bolts	none	Insert through lifting eye holes and case	none
45	Plain steel washer	none	Place two on lifting eye bolts	none
46	Plain nut	none	Tighten two with 7/16 inch socket wrench	none
47	Nut lock	none	Tighten two only 1/16 turn with wrench	none
48	Wood mount plugs (shipping)	none	Place in front and rear recesses of mount brackets	none
49	Plain washers	none	Place over mount plug holes	none
50	Machine bolt	none	Insert through washers, plugs and stand adapters	none
51	Machine bolt nut	none	Tighten on mount bolts (Turn crankcase to upright position at this stage)	moderate
52	Flanged crankshaft oil seal (Note: Seal split must be approximately 5/8 inch from case parting line on top.)	♦ (Lip)	Remove spring. Twist to open split. Place on shaft lip to rear. Align ends. Install spring (53). Pry into case. (See figure 7-2.) Ends must be flush	none
53	Oil seal spring	none	Loop around shaft. Hook ends. With hook tool lift into seal groove. (See figure 7-3.)	none

* Mixture of one part corrosion preventive compound, Specification MIL-C-6529, Type 1, and three parts aircraft engine lubricating oil, Specification MIL-L-6082, grade 1100

† Anti-seize compound, Specification MIL-T-5544. Apply only a film to avoid plugging oil passages

♦ General purpose aircraft lubricating grease, Specification MIL-L-7711

§ Do not tighten until flanged crankshaft oil seal (52) has been pressed into crankshaft recess

Figure 7-1. Crankcase Assembly Procedure (Sheet 3 of 3)

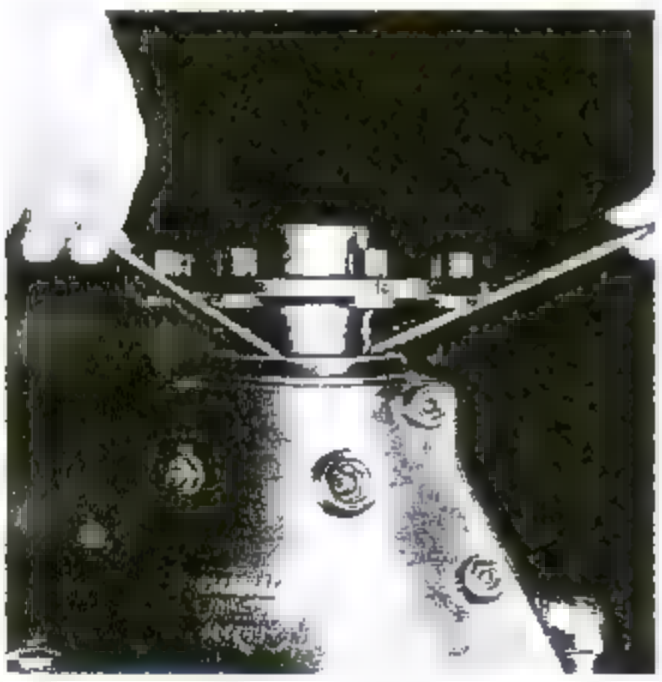


Figure 7-2. Pressing in Flanged Crankshaft Oil Seal

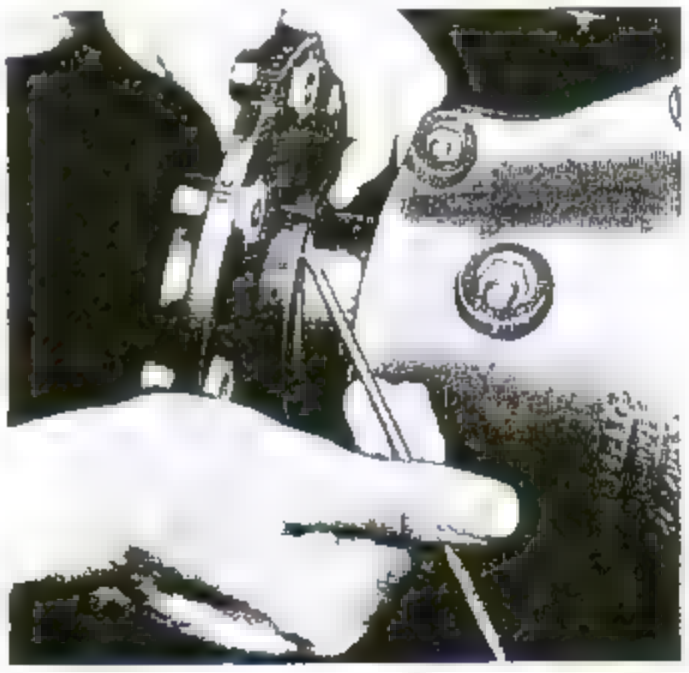


Figure 7-3. Installing Flanged Crankshaft Oil Seal Spring

c. Before tightening two upper and two lower flange attaching bolt nuts and two front through bolt nuts (19 and 28, figure 7–1) pull crankshaft sharply forward to align thrust bearing inserts.

d. Omit the pinion gear and the camshaft gear from engine until the accessory case front half has been attached to the crankcase.

7–11. ACCESSORY CASE FRONT HALF INSTALLATION

7–12. Install the accessory case front half, its attaching parts and other parts illustrated in exploded positions in figure 7–4, in the ascending order of their index numbers. Refer to the legend relative to that figure for procedure details, materials, and identification of parts.

7–13 CYLINDER INSTALLATION.

7–14. PREPARATION.

a. Turn the assembly stand engine bed to place the case assembly in the inverted position. Lock the bed, and set the stand brakes to prevent shifting.

b. Lay all pushrods in a pan of Sun-O-Co Way Oil or castor oil, Federal Specification JJJ-C-86, with crankcase ends slightly elevated to permit air to escape. Place them in a logical order which can be remembered easily, with the intake valve pushrod of each pair to the right of the corresponding exhaust valve pushrod as seen from the crankcase ends. Take care to avoid mixing the pairs or reversing them by position or endwise. The pushrods must be completely covered and should remain immersed until bubbles cease to rise.

c. Work into both surfaces of each pushrod housing flange gasket, in turn, a small quantity of gasoline and oil resistant grease, Specification MIL-G-6032, leaving on the surfaces only the thinnest possible film. As each gasket is treated, place it on one of the crankcase mounting pads for the pushrod housing flanges. Do not lay the treated gaskets elsewhere, since grit will adhere to the grease.

d. Before installing each cylinder and piston subassembly, turn the crankshaft until the corresponding crankpin is at top dead center of its compression stroke (extreme outward position of connecting rod and extreme inward position of both valve lifters); then remove the protector from that cylinder mounting pad.

e. Ascertain that connecting rod bushings, crankpins, and projecting piston skirts are well covered with lubricating oil and that pistons and pins are so located in the cylinders that the pins will extend to the installer's left when the cylinder and piston subassemblies are held in the inverted position, addressing the inverted crankcase.

7–15. INSTALLATION. There is no fixed order of cylinder installation; however, it is advisable to install successive cylinders on alternate sides of the crankcase in order to avoid a large degree of unbalance at any stage of the process. Since piston pins will be pushed in from the left side, it is most convenient to keep the left side of each cylinder position clear. Both of these results may be accomplished by installing cylinders in positions 1, 6, 3, 4, 5, and 2, in that order, turning the crankshaft 1/3 revolution forward (counterclockwise as seen from the front end) after installing each of the first two, a full revolution forward after installing No. 3 and 1/3 revolution backward before installing each of the last two. Having decided upon the numerical order, install each cylinder subassembly in the following manner:

a. Locate the proper pair of pushrods in the pan of oil. Grasp them by their crankcase ends, plugging the ball end oil holes with the thumbs. Insert them in their respective housings without delay, seating the inserted ball ends in the rocker sockets.

b. Cradle the cylinder and piston subassembly in the right arm, keeping the pushrod housings and flange on top. Carry the subassembly to its mounting position.

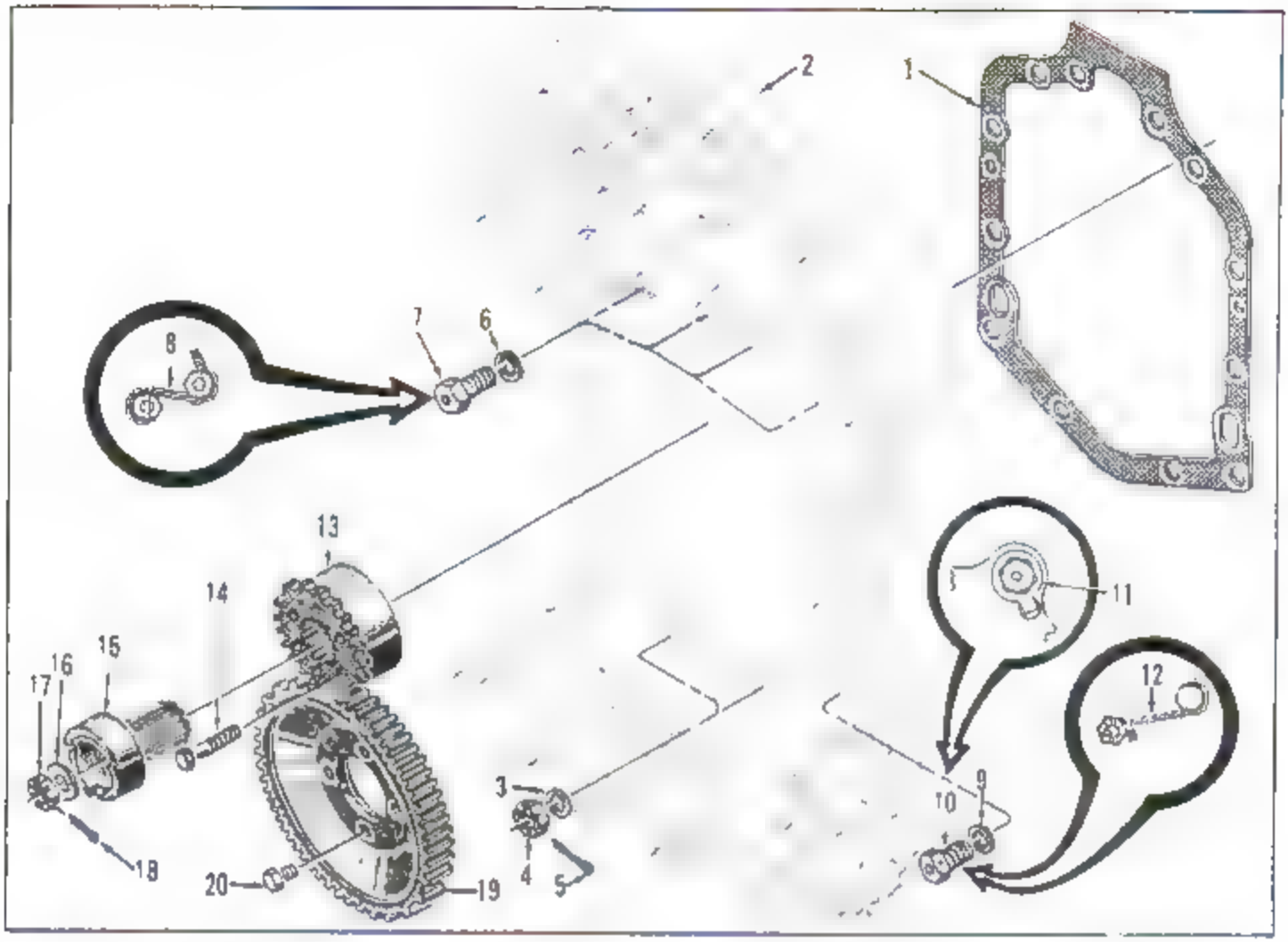
c. With the left hand, lift the connecting rod to a horizontal position, and move the cylinder subassembly inward until the rod bushing is aligned with the piston pin; then push the pin assembly through the bushing and piston until the end plugs are both flush with the piston skirt. (See figure 7–5.) Push the cylinder inward over the piston skirt and pin and onward until the attaching studs have passed through the cylinder flange and pushrod housing flange holes. If the valve lifters were installed "dry", it will be possible to seat the cylinder flange; if not, it must be pulled down with attaching nuts.

d. Run six flanged hex nuts on cylinder retaining studs, and tighten them moderately to hold the cylinder flange firmly on its mounting pad.

e. Screw two flanged hex nuts on through bolts to complete the cylinder attachment.

f. Install three plain washers and plain hex nuts on pushrod housing attaching studs. Tighten the nuts to specified torque and secure them with nut locks.

g. Using a torque indicating wrench and the Group 4 cylinder base nut wrench (see figure 7–6), tighten the cylinder base nuts to the torque specified in Section X for 7/16-20 cylinder base nuts, in the sequence shown in figure 7–7. Then starting with No. 1 (figure 7–7), go around the cylinder base in a clockwise direction, tightening the base nuts to their specified torque. Install nut locks on all through bolts and crankcase studs after the base nuts have been tightened.



INDEX NO	PART NAME	APPLY COMPOUND	ASSEMBLY METHOD	TORQUE (IN LB)
1	Accessory case to crankcase gasket	†	Place over studs on crankcase rear flange	none
2	Accessory case front half subassembly	none	Place over crankcase studs and bolts against gasket	none
	ATTACHING PARTS			
3	Plain steel washer	none	Place two on lower crankcase studs	none
4	Castle shear nut	none	Tighten two with 7/16 inch socket wrench	70-80
5	Cotter pin	none	Insert two through stud holes, bend legs flat	none
6	Plain steel washer	none	Place four on bolts	none
7	Aircraft drilled head bolt	none	Tighten four with 1/2 inch socket wrench	200
8	Lock wire	none	Secure four bolts in pairs, as shown	Nil
9	Plain steel washer	none	Place on bolt	none
10	Aircraft drilled head bolt	none	Tighten with 1/2 inch socket wrench	200
11	Tab washer	none	Tighten with 1/2 inch socket wrench	200
12	Lock wire	none	Secure bolt to cotter pin, as shown	Nil
13	Pinion gear	*	Tap over dowel onto crankshaft	none

Figure 7–4. Attachment of Accessory Case Front Half and Timing Gears (Sheet 1 of 2)

INDEX NO	PART NAME	APPLY COMPOUND	ASSEMBLY METHOD	TORQUE (IN LB)
	ATTACHING PARTS			
14	Drilled hex head screw	*	Tighten six with 7/16 inch socket wrench	140-160
	Lockwire	none	Secure six screws in pairs	none
15	Starter gear	*	Insert into splined gear hole over crankshaft stud	none
	ATTACHING PARTS			
16	Plain steel washer	none	Place over stud inside jaw recess	none
17	Castle sheet nut	none	Tighten with 7/8 inch socket wrench	400-500
18	Cotter pin	none	Insert through stud hole and nut slot. Bend legs flat	none
19	Camshaft gear	*	Place on camshaft flange with punch marked tooth meshed between marked teeth of pinion gear. Turn camshaft to align screw holes	none
	ATTACHING PARTS			
20	Hex drilled head screw	none	Tighten four with 7/16 inch socket wrench. Secure four screws in pairs. (See figure 7–8.)	140-160 Nil
	Lockwire	none		

* Mixture of one part corrosion preventive compound, Specification MIL-C-6529, Type I, and three parts aircraft engine lubricating oil, Specification MIL-L-6082, grade 1100.

▲ Gasoline and oil resistant grease, Specification MIL-L-6082. Apply only a film to avoid plugging oil passages.

Figure 7–4. Attachment of Accessory Case Front Half and Timing Gears (Sheet 2 of 2)

Figure 7–5. Installing Cylinder and Piston

7–16 ACCESSORY CASE COMPLETION

7–17 REAR HALF AND GEARS

a. Rub into the surfaces of a new accessory case front to rear gasket a small quantity of gasoline and oil resistant grease, Specification MIL-G-6032, leaving only the thinnest possible film, and place the gasket over the studs and against the accessory case front half (figure 7–8) parting flange.

b. Lay the accessory case rear half and oil pump

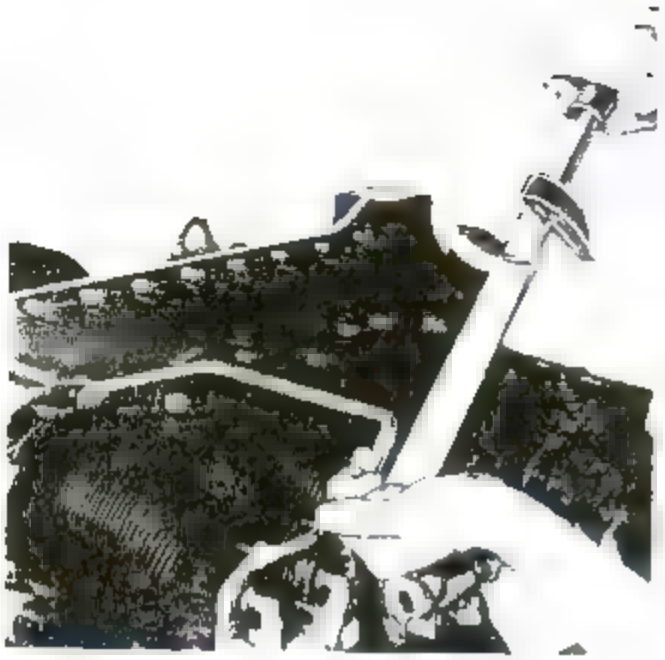


Figure 7-6. Tightening Cylinder Base Nuts

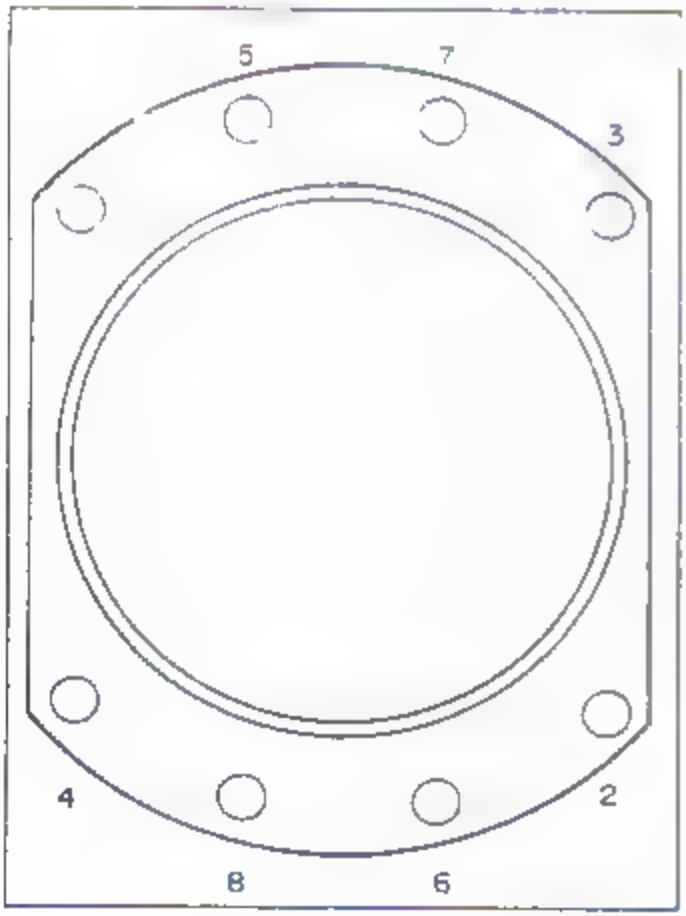


Figure 7-7. Cylinder Base Nut Torque Diagram

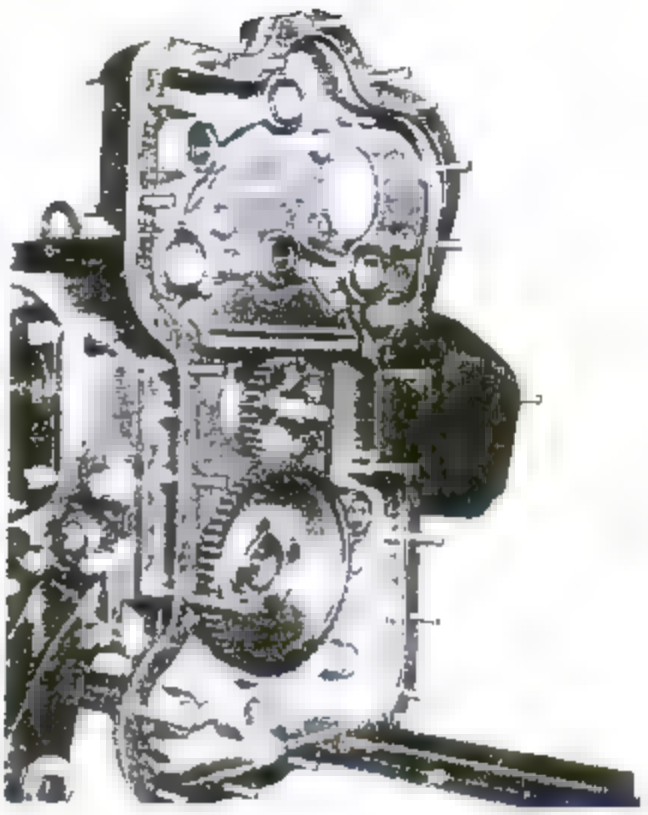


Figure 7-8. Accessory Case Front Half and Timing Gears Installed

subassembly on the work bench with the parting flange upward

c. Lubricate all bushings of both case halves with a mixture composed of one part corrosion preventive compound, Specification MIL-C-6529, Type I, and three parts aircraft engine lubricating oil Specification MIL-L-6082, grade 1100 Lubricate each gear and bushing plug with the same mixture immediately before installing it

d. Insert the long end of the upper hydraulic pump drive plug (1, figure 7-9) (or the splined shaft end of a drive gear, if required) into its bushing in the case front half. Push the plug or gear shaft carefully through the oil seal lip, and make sure that the lip is not pushed ahead of the shaft

e. Insert the long end of the propeller governor drive oil plug (2) (or splined shaft end of the drive gear, if required) into its bushing in the accessory case rear half

f. Insert the longer shaft end (with internal square) of the upper tachometer drive gear (3) into its rear bushing. Lift the case casting to see that the oil seal lip is not reversed as the shaft is pushed through it

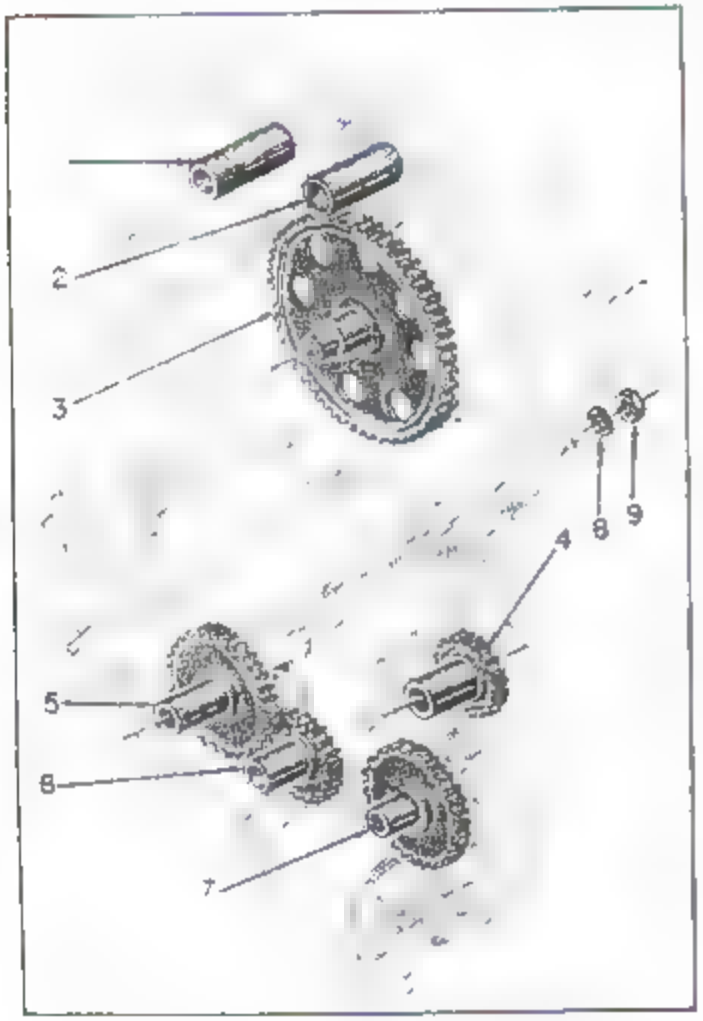
g. In the same manner as described in step f, insert splined shaft ends of the lower hydraulic pump

drive gear (4) and the fuel pump drive gear (5) into their bushings in the case rear half.

h. Insert the shaft of the fuel pump idler gear (6) into its bushing, and mesh the gear teeth with those of the fuel pump drive gear. Seat the gear against the the bushing flange

i. Insert the internally splined shaft of the oil pump drive gear (7) into its bushing, and turn to align and mesh with external splines of the pump driver gear. Push the drive gear home.

j. Hold the accessory case rear half subassembly upright behind the engine, and align its five crankcase stud holes with the studs projecting from the narrow, central portion of the case front half. Slide the case rear half forward over the studs, and work the oil seal lip carefully over the starter jaw. Align the rear half parallel to the front half vertically and horizontally so that the gear shafts and oil plugs will enter the front half bushings. Push the case forward until the gear teeth contact those of the camshaft and pinion gears. Turn gears in the accessory case as necessary to mesh with camshaft and pinion gear teeth. Push the accessory case rear half into contact with the parting flange gasket, and ascertain that nothing interferes with its seating



1 UPPER HYDRAULIC PUMP DRIVE OIL PLUG
2 PROPELLER GOVERNOR DRIVE OIL PLUG
3 UPPER TACHOMETER DRIVE GEAR
4 LOWER HYDRAULIC PUMP DRIVE GEAR
5 FUEL PUMP DRIVE GEAR
6 FUEL PUMP IDLER GEAR
7 OIL PUMP DRIVE GEAR
8 PLAIN STEEL WASHER (TWO REQUIRED)
9 PLAIN NUT (TWO REQUIRED)

Figure 7–9. Accessory Case Rear Half and Gear Installation

k. Place two plain steel washers (8) on the accessory case rear half studs projecting forward through the accessory case front half. Run two plain hex nuts (9) on these studs and tighten finger tight.

l. Attempt to oscillate each of the accessory drive shafts to check roughly for gear backlash. There should be a preceptible movement of each drive gear. If no backlash or a very large backlash is observed at any drive, remove the case rear half and gears to determine and correct the cause before completing the assembly

7–18. ACCESSORY CASE, ADAPTERS, AND COVER ATTACHMENT. Case attaching parts not yet installed and the various accessory drives, adapters, and pad covers are illustrated in exploded positions in figure 7–10. Install parts in the ascending order of their index numbers, using tools, materials, and methods described in the legend which accompanies that illustration. If a hydraulic or other pump is to be installed prior to the run-in test, omit the appropriate cover and its attaching parts, unless the engine is to be stored pending such installation. Covers for the starter and generator adapters may be procured from the engine manufacturer for installation during periods of storage when starters or generators are not installed.

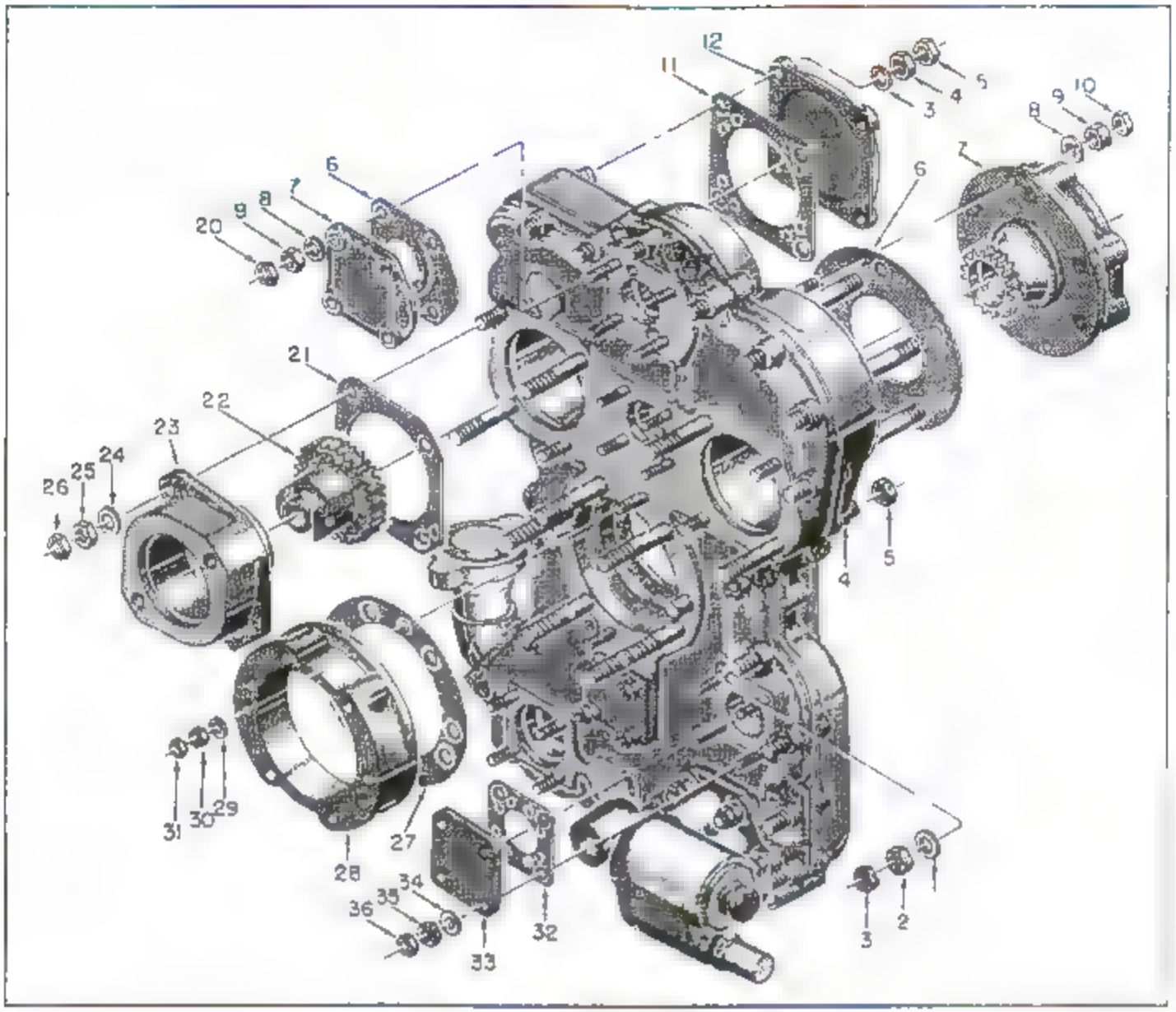
7–19. OIL SUMP INSTALLATION.

7–20. Install the sump subassembly on the inverted engine in the following steps.

a. Push a 1-inch ID x 4-inch long reinforced synthetic rubber hose connector over the accessory case drain nipple, and place on it two hose clamps.

b. Coat the first three threads of a hose adapter with a film of anti-seize compound, Specification MIL-T 5544, and screw the adapter into the oil pump pipe tapped (bottom) inlet port. Tighten the adapter with a 1-1/4 inch open or box end wrench.

c. Coat the first three pipe threads of flared tube and pipe thread elbow with anti-seize compound, and screw the elbow into the pipe tapped (rear) discharge port of the oil pump. Tighten the elbow with a 7/8-inch



INDEX NO	PART NAME	APPLY COMPOUND	ASSEMBLY METHOD	TORQUE IN LBS
1	Plain steel washer	none	Place 22 on front half and crankcase studs	none
2	Plain nut	none	Tighten 22 with 1 2 inch socket wrench in stages, progressing around case	200
3	Nut lock	none	Tighten 22 only 1 6 turn with wrench	Nil
4	Plain nut (See 9, figure 7-9)	none	Tighten two with 1 2 inch socket wrench	200
5	Nut lock	none	Tighten two only 1 6 turn with wrench	Nil
6	Generator adapter gasket	‡	Place on studded case pad	none
7	Generator adapter and gear sub-assembly	*(Gear)	Slide over case studs and against gasket	none
	ATTACHING PARTS			
8	Plain steel washer	none	Place two on accessory case studs	none

Figure 7-10 Accessory, Adapter and Cover Attachment (Sheet 1 of 2)

INDEX NO	PART NAME	APPLY COMPOUND	ASSEMBLY METHOD	TORQUE (IN LB
9	Plain nut	none	Tighten two with 7/16 inch socket wrench	75
10	Nut lock	none	Tighten two only 1/6 turn with wrench	Nil
11	Gasket	‡	Place on upper hydraulic pump pad	none
12	Upper hydraulic pump pad cover	none	Place over studs and against gasket	none
	ATTACHING PARTS			
13	Plain steel washer	none	Place four on accessory case studs	none
14	Plain nut	none	Tighten four with 1/2 inch socket wrench	200
15	Nut lock	none	Tighten four only 1/6 turn with wrench	Nil
16	Gasket	‡	Place on studded governor mount pad	none
17	Propeller governor pad cover	none	Place over studs and against gasket	none
	ATTACHING PARTS			
18	Plain steel washer	none	Place four on accessory case studs	none
19	Plain nut	none	Tighten four with 1/2 inch socket wrench	200
20	Nut lock	none	Tighten four only 1/6 turn with wrench	Nil
21	Magneto adapter gasket	‡	Place one on each magneto adapter pad	none
22	Magneto cluster gear assembly	*	Insert one in each magneto adapter	none
23	Magneto adapter assembly	none	Turn crankshaft to full advance firing angle (refer to para 7–30). Slide on studs. Mesh gear teeth so that slot of left magneto cluster gear is vertical (right cluster gear slot horizontal)	none
	ATTACHING PARTS			
24	Plain steel washer	none	Place two on small studs for each adapter	none
25	Plain nut	none	Tighten two on studs to retain each adapter	75
26	Nut lock	none	Tighten four only 1/6 turn with wrench	Nil
27	Starter adapter gasket	‡	Place on studded adapter pad	none
28	Starter adapter	none	Place over studs and against gasket	none
	ATTACHING PARTS			
29	Plain steel washer	none	Place two on accessory case studs	none
30	Plain nut	none	Tighten two with 7/16 inch socket wrench	75
31	Nut lock	none	Tighten two only 1/6 turn with wrench	Nil
32	Gasket	‡	Place on lower hydraulic pump pad	none
33	Vacuum pump adapter cover (shipping)	none	Place on lower hydraulic pump pad if no vacuum pump is to be installed	none
	ATTACHING PARTS			
34	Plain steel washer	none	Place four on accessory case studs	none
35	Plain nut	none	Tighten four with 7/16 inch socket wrench	75
36	Nut lock	none	Tighten four only 1/6 turn with wrench	Nil

* Mixture of one part corrosion preventive compound, Specification MIL-C-6529, Type I, and three parts aircraft engine lubricating oil, Specification MIL-L-6082, grade 1100.

‡ Gasoline and oil resistant grease, Specification MIL-L-6032. Apply only a film to avoid plugging oil passages.

Figure 7–10 Accessory, Adapter and Cover Attachment (Sheet 2 of 2)

open end wrench so that the flared tube connector thread points obliquely upward and to the 1, 3, 5 cylinder side.

d. Invert the sump subassembly, and lower it into position on the crankcase, guiding its rear drain nipple into the hose on the accessory case nipple, its upper inlet tube "O" ring into the crankcase rear drain hole, and its bracket holes over six crankcase studs

e. Attach the sump mount brackets with six plain washers, plain nuts, and nut locks

f. Place a plain washer over each rear engine mount bracket to support bracket stud and place the two sump side support brackets over them and in position. Attach each side support bracket to its retaining stud with a plain washer and a plain nut. Attach the brackets to the sump with drilled hex head bolts. Tighten bolts and nuts to specified torque Secure the stud nuts with nut locks and the bolts to the brackets with lock wire.

g. Space the rear drain hose on the accessory case and sump nipples and tighten the two hose clamps in positions between nipple beads and hose ends

h. Push the oil suction tube hose connector over the oil pump adapter and tighten one hose clamp in a position between the adapter bead and the pump end of the hose. Tighten the other hose clamp on the suction tube end of the hose

i. Check tightness of the oil dilution connection plug and oil drain plug. Tie these together with twisted lock wire

j. Place the flared tube union nuts of the oil pump discharge hose assembly on the oil pump discharge elbow and crankcase connection elbow (12, figure 6-6), leading the hose inside the right side oil sump support bracket, and tighten the union nuts securely. Attach the hose to the sump support bracket with two hose clamps, a bolt, and a self locking nut. (See 2, 3, 4 and 5, figure 2-5)

7-21. INDUCTION SYSTEM.

7-22 MANIFOLD AND FRONT OIL DRAIN TUBE.

a. Rub into the surfaces of the intake and oil drain manifold front and rear gaskets a small quantity of gasoline and oil resistant grease, Specification MIL-G-6032, and place them on the crankcase pads.

b. Coat the first three threads of a square head 1/8-inch pipe plug with anti-seize compound, Specification MIL-T-5544, and screw the plug tightly into the oblique tapped hole in the right front corner of the square portion of the manifold casting, or similarly install a tube connector for a manifold pressure gage line if required for the run-in test. If a connector is installed, cover it with non-hygroscopic tape or a plastic screw cap.

c. Place the inverted manifold casting on its mounting pad gaskets with bolt holes aligned

d. Swing the oil sump front support bracket into position over the left rear manifold bolt hole Place a plain washer on each of the two manifold rear attaching bolts and insert them through the manifold casting Screw these bolts in with fingers only

e. Treat a second manifold front gasket with a minimum film of gasoline and oil resistant grease, Specification MIL-G-6032, and place it on the manifold front mounting boss pad. Substitute an oil drain cover if the drain hole is bored through If not, neither a gasket nor a cover will be required Screw the front bolts into the crankcase holes, then tighten all four bolts evenly to specified torque, and connect them in pairs with twisted lock wire

f. Tighten the oil sump to front support bracket bolt, and secure it to the support tube with lock wire

g. Push the sump to oil drain manifold hose connector forward to cover an equal portion of each tube end and tighten the two hose clamps in such positions as to hold the hose firmly It should be impossible to turn the hose by hand if the clamps are properly installed and the hose is dry

7-23. INTAKE TUBES.

a. Push the hose connector of each intake tube subassembly over one of the intake manifold outlets until the hose stops against the small lug on the casting.

b. Push the curved end of each tube into its cylinder port and align the loose flange and cylinder bolt holes.

c. Place an internal tooth lock washer, then plain washer on each of the 12 intake tube flange attaching hex head bolts. Insert two bolts through each flange and screw them all into the cylinder Helicoils Tighten the two bolts on each intake tube flange evenly to specified torque.

d. Locate the two clamps on each intake tube hose connector, midway between the nearest hose end and tube end, and tighten all 12 clamps enough to seal

CAUTION

It is important to maintain perfect roundness of the intake tube ends. Any distortion due to rough handling of these soft aluminum tubes or over tightening of clamps will permit air leakage into the manifold, regardless of clamp tightness. Lean mixtures caused by such leaks may result in severe damage to the engine.

7–24. CARBURETOR. Install the carburetor to manifold gasket on the studded manifold pad. Check the carburetor for installation of all plugs and the fuel inlet and vent line fittings required for testing (or plugs). Invert the carburetor and place it on the pad gasket. Install four plain washers and plain nuts. Tighten the nuts securely and install nut locks. Cover the carburetor bottom flange with cardboard or other suitable stiff cover to keep out dust. The cover should project outside the flange edges so that its presence will not be overlooked during test installation, in case it should adhere. Attach the cover with tubular spacers and plain hex nuts.

7–25. FUEL PUMP. While the engine remains inverted, install the fuel pump on its mounting pad, using a new gasket. Mount the fuel pump with its drain hole upward (so that it will be downward in flight). The fuel pump is installed on a gasket placed directly on the accessory case mounting pad. Attach the fuel pump with four plain washers, plain nuts, and nut locks of required size.

7–26. PRIMER JET. Coat the first three threads of the jet assembly with a thin film of anti-seize compound, Specification MIL-T-5544, and screw the jet into the 1/8-inch pipe tapped hole in the intake manifold in front of the carburetor mounting pad. Tighten the jet with a 9/16-inch open or box end wrench and install a 1/8-inch square head pipe plug, lubricated with anti-seize compound, in its connector hole.

7–27. PRIMING SYSTEM. After the engine has been turned upright, coat the threads of the six union nipples installed in the primer distributor and the six priming jet nipples installed in cylinder heads with a film of anti-seize compound, Specification MIL-T-5544. Attach the six priming tubes between the distributor union nipples and the jet nipples, making sure that the tube cones and nipple cone seats fit perfectly. Run the tube coupling nuts on the nipple threads and tighten them moderately. The two longest priming tubes are for No. 1 and 2 cylinders, those of medium length for No. 5 and 6, and the two shortest for No. 3 and 4. Locate the rubber tube protectors near the middle of the tubes. Since the tube brackets are attached to the aircraft baffles, they should not be installed until the engine is prepared for shipment.

7–28. VALVE ROCKER COVERS

7–29. Place an internal tooth lock washer, then plain washer on each of 42 fillister head screws. Ascertain that the six rocker covers have the same flange shape and bolt hole spacing as cylinder head flanges. Lay the covers, flange sides up, on the bench. Check six new cover gaskets for conformity with cover flange shape. Rub into their surfaces a small quantity of gasoline and oil resistant grease, Specification MIL-G-6032. As each gasket is treated, place it on one of the six covers. Apply lubricating oil and corrosion preventive mixture to rockers and valve springs with a squirt can. Place each cover and its gasket, in turn, on a cylinder flange, and attach it with seven of the fillister head screws, tightened in stages with a screw driver and progressing around the cover. Use a screw driver socket and torque indicating handle to apply final tightening torque of specified value.

7–30. IGNITION SYSTEM INSTALLATION AND TIMING

7–31. INSTALLATION AND TIMING OF MAGNETOS

a. Plug both No. 1 cylinder spark plug holes as shown on the ignition wiring diagram (figure 7–11) with the fingers, and turn the crankshaft rapidly clockwise, as seen from the front end, until a suction is felt in the cylinder. No. 1 piston is now on its compression stroke.

b. Install a Time-Rite piston position indicator in the No. 1 cylinder upper spark plug hole, with the instrument's white celluloid scale toward the rear of the engine and with the slide slot aligned with the nearest No. 1 rocker cover screw. (See figure 7–12.)

c. Turn the crankshaft slowly counterclockwise, as seen from the front end, until No. 1 piston has passed top dead center. The Time-Rite arm will be starting down again and the slide will be left at the position corresponding to top dead center. Move the white scale to align its zero mark with the slide index line. Friction of the clips will hold it there.

d. Back up the crankshaft (clockwise as seen from front) and place the slide against the Time-Rite arm. The piston position must be earlier in the stroke than 26 degrees B.T.C.

e. Tap the crankshaft turning bar counterclockwise until the Time-Rite slide index is exactly on 26 degrees B.T.C.

f. With No. 1 piston at its full advance firing angle, as described in step e, the left magneto cluster gear coupling slot should be approximately vertical and the right gear slot horizontal.

g. To place the magneto in the No. 1 firing position, remove the hex head screw plug at the top of the case, and turn the impulse coupling cup backward until the white tooth of the large distributor gear is aligned with the timing pointer, visible through the inspection hole.

h. Before installing the magneto, remove the breaker cover plate at the rear, and insert a thin insulator strip between the case and the breaker grounding spring, or leave the cover in place, and install in the switch wire terminal socket a test lead made up of a short wire and a terminal kit.

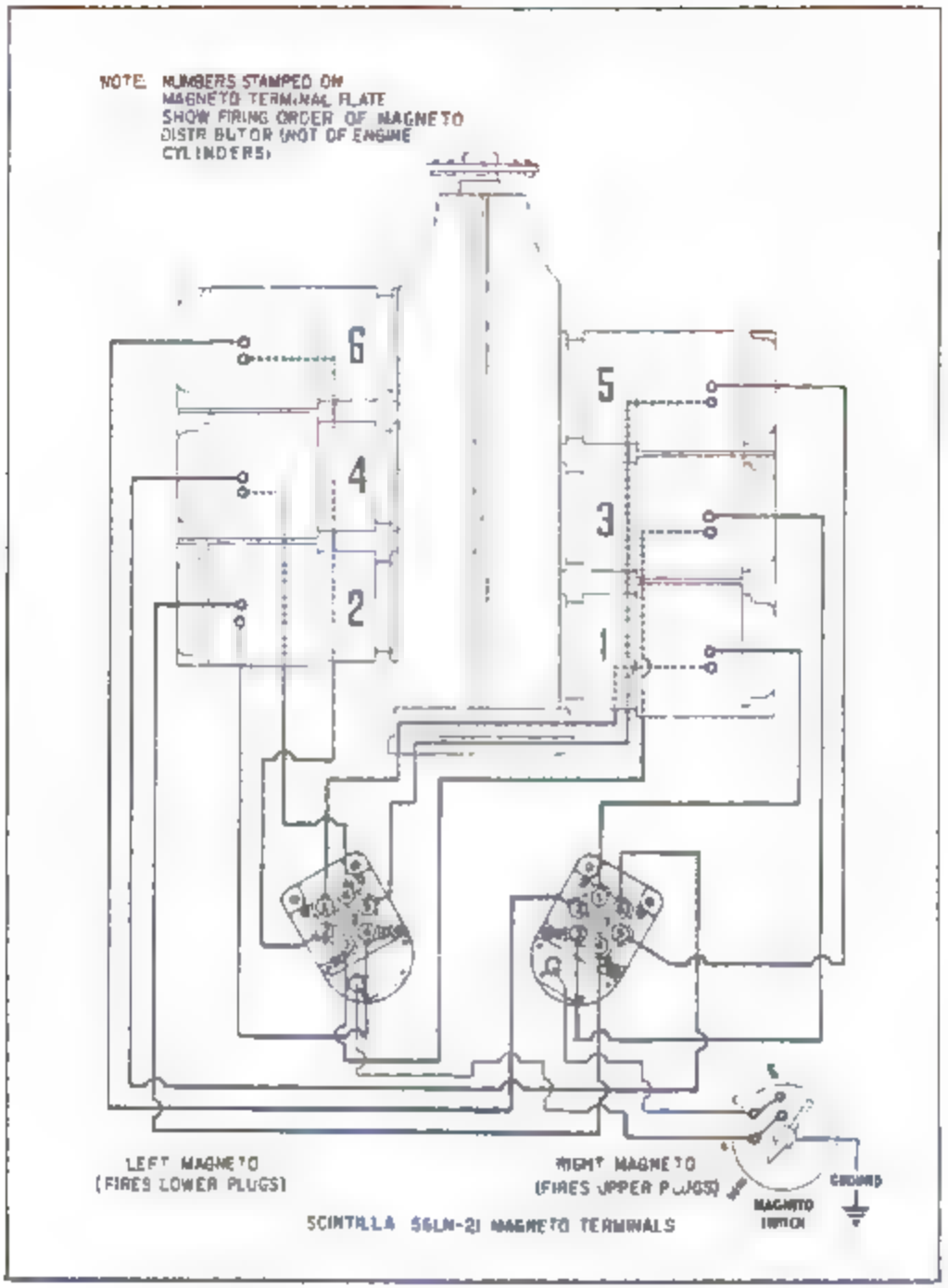


Figure 7-11. Ignition Wiring Diagram

i. Insert one retainer in the rear slot of each magneto cluster gear and place two rubber drive coupling bushings in each retainer.

j. Place a magneto flange gasket on each magneto mounting pad.

k. With No. 1 piston in its full advance firing position (step e), align the magneto impulse coupling drive lugs with slots between drive coupling bushings, and place the magnetos on their gaskets. Attach each magneto with two special flat washers and plain nuts, tighten with the fingers only.

l. Turn the left magneto to its extreme clockwise position, as seen from the rear. Inspect the magneto rotor position (step g). The timing marks must be approximately in No. 1 firing position.

m. Place a Scintilla No. 11-851, or equivalent, timing light so that it can be seen from the magneto installer's position. (See figure 7-12.) Connect the ground lead to the left magneto case and either of

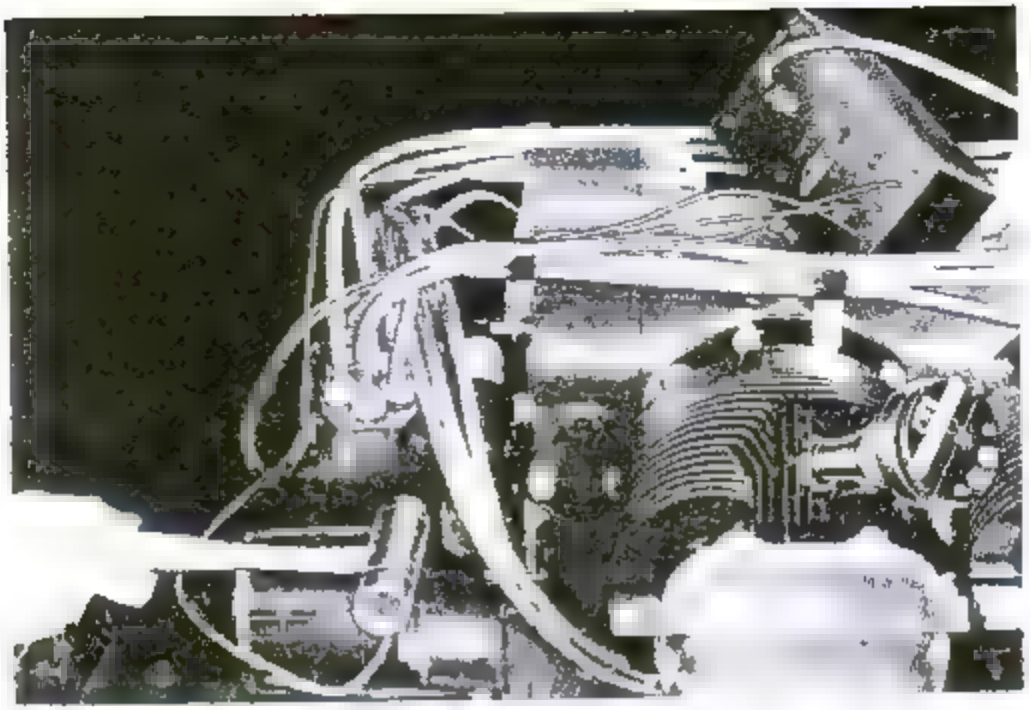


Figure 7–12. Timing Ignition

the other leads to the insulated breaker point or to the test lead installed in the switch wire terminal socket (step h). Plug the timing light power cable into a 110-volt, alternating current outlet. The timing light should indicate that the magneto breaker is closed. If it does not, locate and correct the trouble If no trouble is found in the light circuits, the magneto drive gear will have to be re-meshed one tooth counterclockwise from its original position

n. Tap the magneto case counterclockwise with a non-marring hammer until the timing light indicates that the breaker points have just opened. (See figure 7–12) Tighten the magneto attaching nuts moderately to hold this position

o. Repeat steps l through n to time the right magneto

p To verify the timing of each magneto, connect the timing light to its insulated breaker point, either directly or through a test wire and terminal assembly installed in the switch wire socket (step h). Then back up the crankshaft to approximately 36 degrees B T.C. This will not allow the impulse coupling latch to engage the stop stud on the magneto case. (If the latch is inadvertently engaged by more crankshaft movement, back up the shaft two revolutions from the timing position plus 10 degrees.) Place the Time-Rite slide against the arm and ascertain that the lamp circuit is operating, then place the slide at 26 degrees B T.C. Tap the crankshaft forward until the Time-Rite lamp lights to indicate that No. I piston is at its full advance firing position. At the same instant, the timing light will indicate that the magneto breaker points have just opened if timing is correct.

q. Apply final tightening torque to the magneto attaching nuts and secure them with four nut locks.

r. Remove the insulator strips from magneto grounding springs and replace their timing inspection hole plugs or remove the test lead from the switch wire terminal socket of the last magneto tested Replace the breaker cover on the magneto

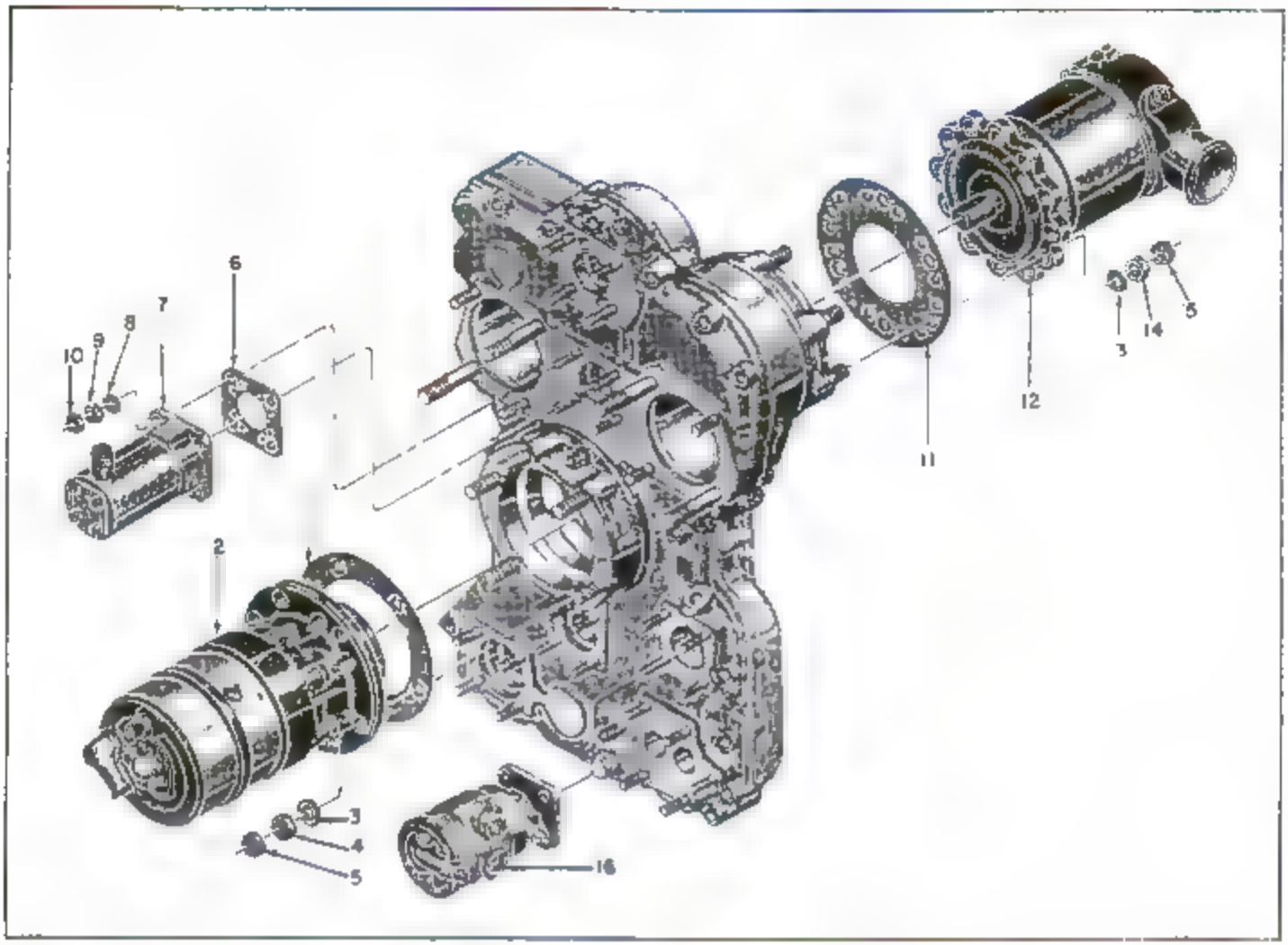
7–32. INSTALLATION OF IGNITION HARNESS.

a. Lay the upper ignition assembly on the cylinders and the lower assembly on the intake pipes.

b. Attach the upper spark plug cable outlet plate to the right magneto and the lower plug cable plate to the left magneto. Push the rubber plate grommets into the magneto recesses carefully and install four lock washers and fillister head screws to retain each outlet plate.

c. Install the single conduit brackets on No. 5 and 6 lower spark plug cable conduits and attach them to lower rear pushrod housing flange studs of center cylinders with the flange retaining washers, nuts, and nut locks

d. Remove the nut locks, nuts, and washers from the upper rear attaching studs of both engine rear mount brackets. Bend the 3-cable brackets on left and right lower ignition conduits to right angles, above the attaching bolt holes, and away from the shorter bracket ends. Place the lower 1, 3, 5 conduit bracket hole on the open stud so that the bracket loop is downward. Install the opposite conduit bracket on its stud so that its loop is upward. Replace the attaching parts.



INDEX NO	PART NAME	APPLY COMPOUND	ASSEMBLY METHOD	TORQUE (IN LB
1	Gasket	‡	Place over studs, on starter adapter	none
2	Starter	♦(jaw)	Place flange over studs, on gasket	none
	ATTACHING PARTS			
3	Plain steel washer	none	Place 6 on starter retaining studs	none
4	Plain nut	none	Tighten 6 with 9/16 inch socket wrench	300
5	Nut lock	none	Tighten 6 only 1/6 turn with wrench	Nil
6	Gasket	‡	Place over studs on upper tachometer drive pad	none
7	Tachometer generator	♦(shaft)	Align shaft with square hole in drive. Place mounting flange over studs, on gasket	none
	ATTACHING PARTS			
8	Plain steel washer	none	Place 4 on tachometer generator retaining studs	none
9	Plain nut	none	Tighten 4 with 7/16 inch socket wrench	75
10	Nut lock	none	Tighten 4 only 1/6 turn with wrench	Nil

Figure 7–13. Installation of Accessories (Sheet 1 of 2)

INDEX NO	PART NAME	APPLY COMPOUND	ASSEMBLY METHOD	TORQUE (IN. LB.)
11	Gasket	‡	Place over studs, on generator adapter	none
12	Generator	◊(shaft)	Align splines with drive gear splines Place mounting flange over studs, on gasket	none
	ATTACHING PARTS			
13	Plain steel washer	none	Place 6 on generator remaining studs	none
14	Plain nut	none	Tighten 6 with 9/16 inch socket wrench	300
15	Nut lock	none	Tighten 6 only 1/6 turn with wrench	Nil
16	Vacuum pump	◊(shaft)	Use gasket and attaching parts 32, 34, 35 and 36, figure 7–10	–

‡ Gasoline and oil resistant grease Specification MIL-G-6032 Apply only a film to avoid plugging oil passages
◊ General purpose aircraft lubricating grease, Specification MIL-L-7711.

Figure 7–13. Installation of Accessories (Sheet 2 of 2)

e. If harness is Part No. 536043 (5 mm. cable), place two halves of one of the twin cable clamp assemblies on No. 3 and 5 upper conduits ahead of No. 1 cylinder position and attach them with screw and nut. Attach a clamp to No. 4 and 6 upper conduits in the same manner.

f. Place the large band clamp around the No. 1, 3, 5 lower and 2, 4, 6 upper conduits where they cross over behind the magnetos.

7–33 INSTALLATION OF SPARK PLUGS

a. Coat the threads with BG mica thread lubricant. See that each spark plug is equipped with a solid copper gasket and that its electrodes are apparently properly gapped

b Screw each spark plug into cylinder hole with fingers. If excessively tight fit is noticed, remove plug and determine cause. Do not force spark plug into damaged insert bushing or install one with a deformed thread

c. Tighten all spark plugs to the torque specified for the size used, using a deep socket or special spark plug socket and a torque indicating handle.

d. Before installing each spark plug contact sleeve, coat it with a thin film of insulating and sealing compound, Specification MIL-I-8660. Do not apply this compound with the fingers, since perspiration seriously reduces its insulating value. Do not permit any of compound to be scraped off on spark plug thread, since it might destroy continuity of ignition shielding

e Insert each contact sleeve carefully into the corresponding spark plug well, and tighten the elbow union nuts with fingers, holding the elbows in alignment. Tighten each elbow union nut moderately with a wrench, but only enough to keep the elbow from turning.

Note

Where Helicoil inserts or stainless steel spark plug bushings are used, the use of thread lube is not mandatory.

7–34. STARTER, GENERATOR, AND TACHOMETER GENERATOR INSTALLATION.

7–35. The starter, generator, tachometer generator, vacuum pump, and gaskets and attaching parts for these accessories are illustrated in exploded positions in figure 7–13. Install these parts in the ascending order of their index numbers and by the methods described in the legend which accompanies the illustration

7–36. FITTINGS, ACCESSORIES, AND CLOSURES.

7–37. If the engine is to be tested immediately, fittings required to connect test stand instruments may be installed in lieu of plugs specified in Sections VI and VII. Such fittings must be covered with non-hygroscopic tape or appropriate plastic caps to exclude moisture and dust. The oil line connection elbows and the crankcase breather elbow must be similarly covered. Accessories to be tested on the engine may be installed in lieu of drive covers specified in Sections VI and VII. All unused accessory drives must be covered during any period of storage. For this purpose, use accessory gaskets and metal covers designed for the specific applications.

7–38. Install the oil gage rod in the sleeve at the left side of the oil sump neck

7–39. ASSEMBLY INSPECTION

7–40. Backlashes, end clearances, valve timing, and

ignition timing shall be inspected at the appropriate stages of assembly by qualified personnel, using methods described in this section wherever standard dimensional inspection techniques do not apply

7–41. Inspect the completed engine for proper attachment of all parts and correct installation of all cotter pins, nut locks, and lock wires visible from the exterior Make sure that all engine openings are covered

Note

If an overhauled engine will be stored longer than 48 hours prior to the run-in test, prepare it for storage in accordance with TM 1-2R-1-11

SECTION VIII

TESTING AFTER OVERHAUL

Note

The instructions contained in this section and TM 1-2R-1-12 are applicable to and will be followed by personnel engaged in the testing of aircraft engines after overhaul

8–1. ENGINE LUBRICATING OIL.

8–2. TYPE REQUIRED. During the run-in test, the engine shall be supplied with aircraft engine lubricating oil conforming to specification MIL-L-6082, grade 1100

8–3. ALLOWABLE OIL TEMPERATURES. Oil inlet temperature shall not exceed 102°C (215°F) at any time The oil inlet temperature shall rise above 32°C (90°F) before crankshaft speed is allowed to exceed 900 rpm. Adequate means of warming and cooling lubricating oil to maintain operation within these limits shall be provided.

8–4. QUANTITY OF LUBRICATING OIL. The oil sump capacity of the engine is 10 U.S. quarts, with a 10 percent expansion space. The sump shall be filled to this level before the test is started. The oil level, as indicated by the bayonet oil gage, shall not be allowed to decrease below five quarts at a time while the engine is running, with the exception of the preservative period and whenever an outside source is used and the lubricant is returned thereto.

8–5 OIL PRESSURE. Engine oil pressure shall be measured continuously throughout the test by means of an accurate gage located in full view of the operator and connected to the tapped hole in the crankcase provided for this purpose Oil pressure at idling speed shall be at least 10 psi. Oil pressure shall be 40-75 psi at speeds above 1500 rpm and shall be regulated during the test so as to reach 68-72 psi at 2300 rpm with oil inlet temperature of 75°C (167°F).

8–6. OIL FLOW AND CONSUMPTION. When the engine is operated on a rigid test stand at maximum continuous rated speed and power, supplied with the lubricant specified in paragraph 8–2, at a temperature of 75°C (167°F) and a pressure of 68-72 psi, the rate of oil flow shall not exceed 70 pounds per minute and a rate of oil consumption not in excess of 3.42 pounds per hour. At take-off speed and power, with the same oil temperature and pressure, oil flow shall not exceed 78 pounds per minute.

8–7. HEAT REJECTION When operated within the limits specified in paragraph 8–6, the engine shall not exceed a heat rejection rate of 500 BTU per minute at 2300 rpm or 560 BTU per minute at 2600 rpm

8–8. FUEL

8–9. TYPE AND GRADE OF FUEL REQUIRED During the run-in test, the engine shall be supplied with gasoline conforming to Specification MIL-G-5572, grade 80.

8–10. INSTRUCTIONS FOR USING FIGURE 8–1.

a. Locate observed RPM on bottom scale.

b. Follow the vertical line, corresponding to observed RPM to the point where it intersects the oblique line corresponding to observed carburetor air temperature

c. Read desired Absolute Dry Manifold Pressure (ADMP) (to produce 184.5 HP) on the horizontal line which passes through the intersection located in step b

d. With the desired and observed Absolute Dry Manifold pressure and the constant BHP known, the following formula may be used to calculate the actual BHP produced at the time of test (see figure 8–1 for constant BHP):

$$\frac{\text{Actual ADMP}}{\text{Desired ADMP}} \times \text{Constant BHP} = \text{Actual BHP (at time of test)}$$

8–11. FUEL PRESSURE. Normal operating fuel pressure is 10 psi. The allowable range of fuel pressure is 9-15 psi. Fuel pump pressure regulators shall be adjusted to these limits.

8–12. FUEL CONSUMPTION. When operated at maximum continuous rated power and speed, the fuel consumption limits are 111.5 pounds per hour maximum and 108.5 pounds per hour minimum.

8–13. FUEL SYSTEM CONNECTIONS. It will be necessary to make the following fuel connections:

a. Connect a fuel hose from the fuel supply tank to the fuel pump port marked "IN" (17, figure 8–2).

b. Connect a fuel supply hose from the fuel pump port marked "OUT" (16, figure 8–2) to the carburetor inlet port (19, figure 8–3).

c. Remove the pipe plug from the carburetor vapor vent port (10, figure 8–3), and connect a vent line. Connect the other end of the vapor vent line to a point in the fuel line between the fuel pump and carburetor inlet port, so that the vent line rises continuously from the carburetor vapor vent to its connection in the fuel line.

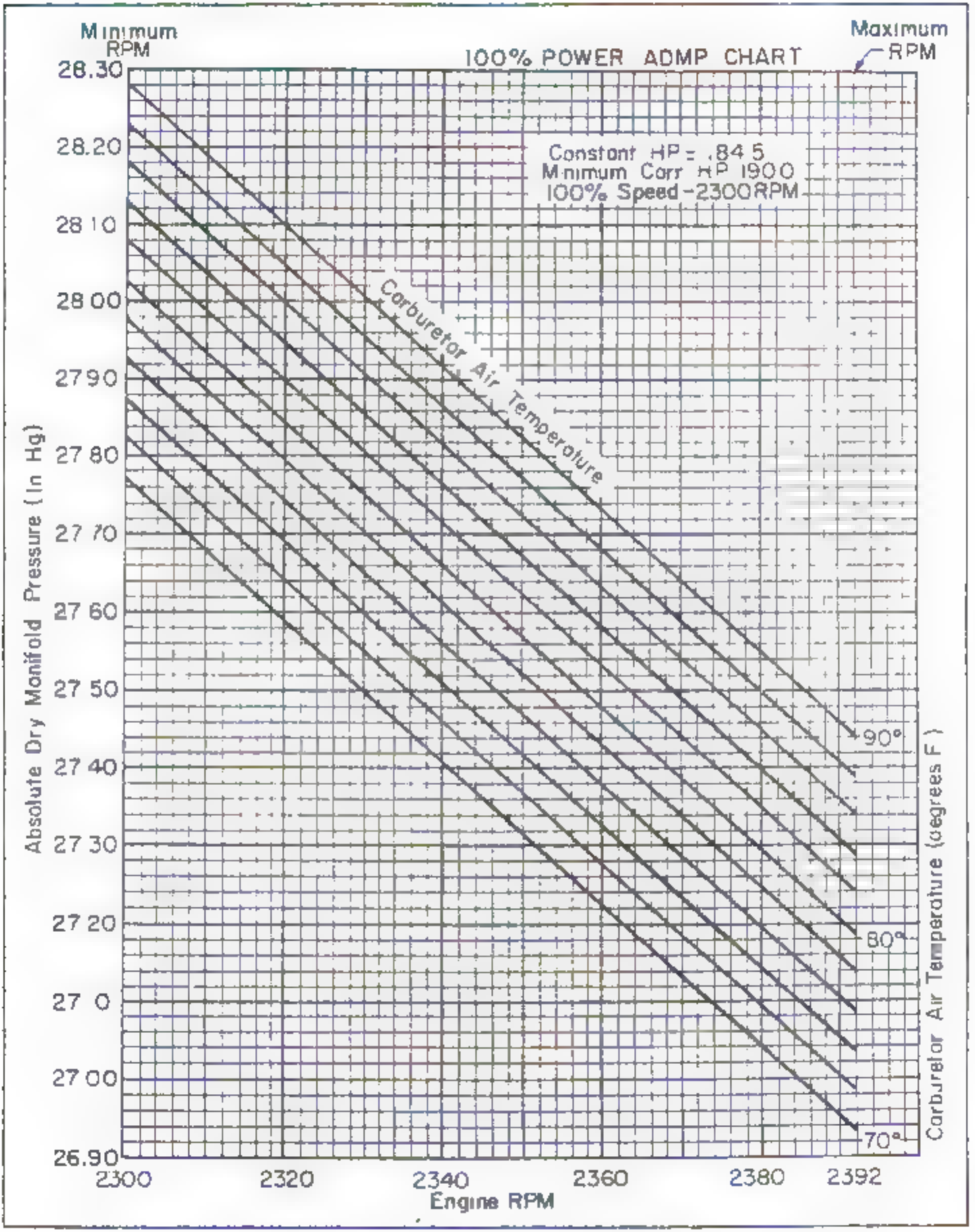
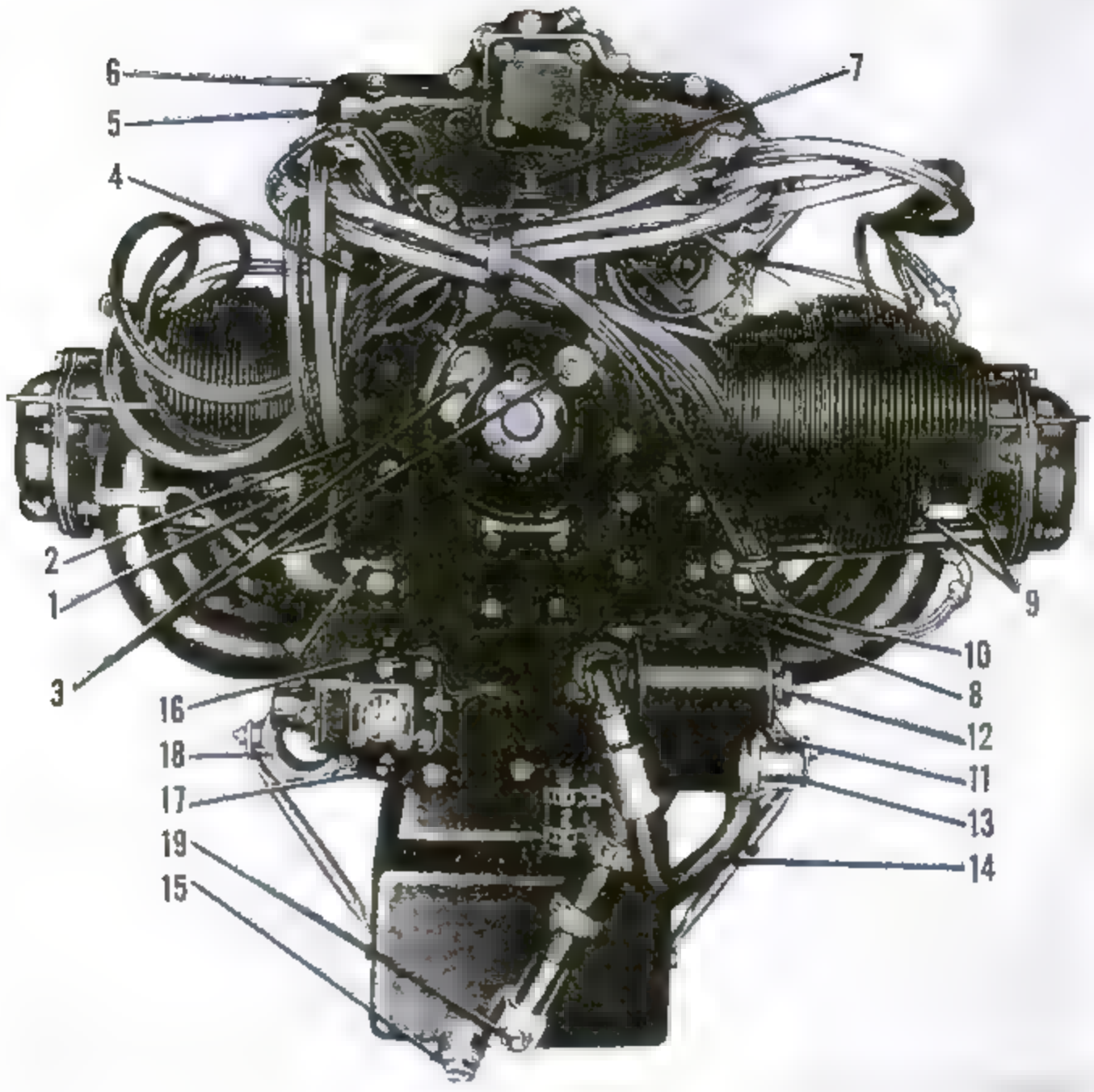
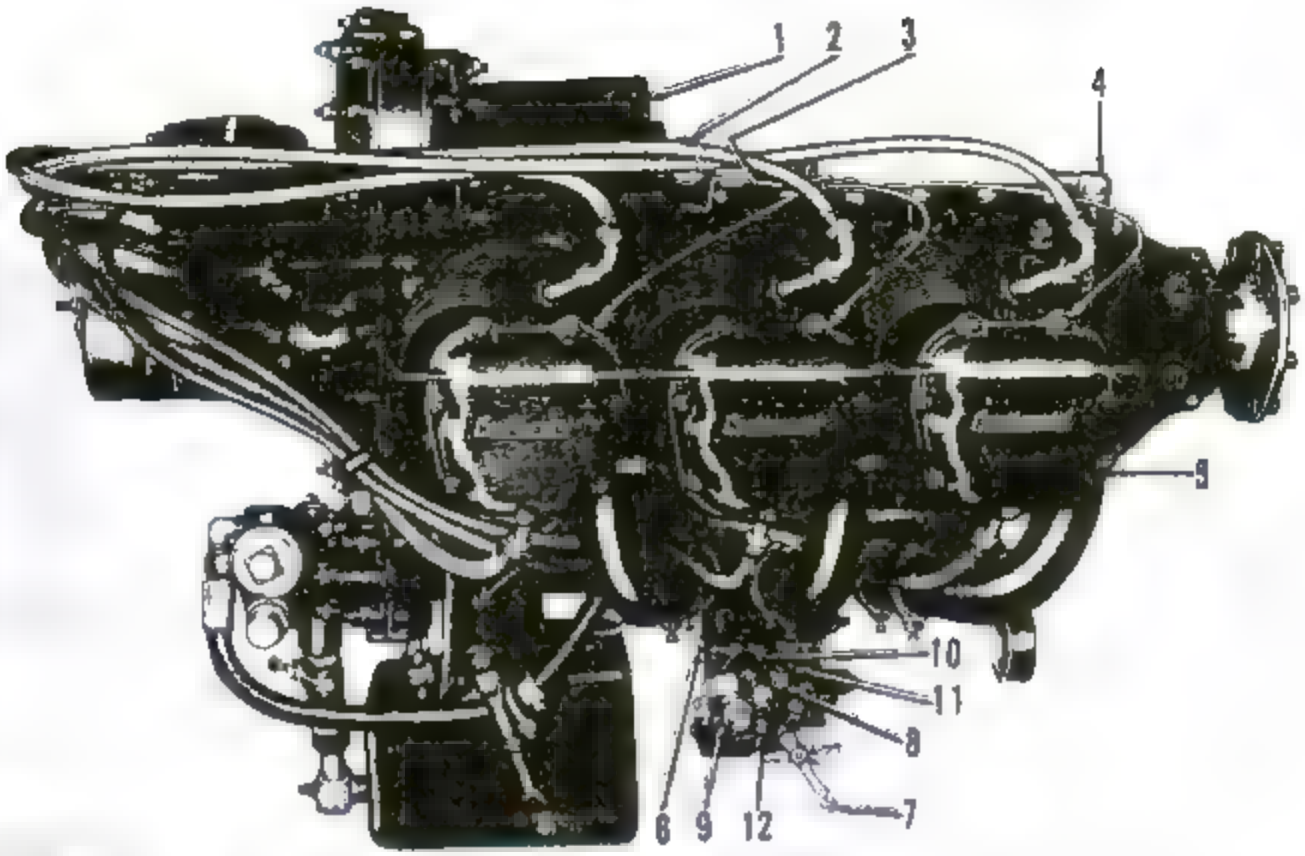


Figure 8-1 Absolute Dry Manifold Pressure, RPM, and Carburetor Air Temperature



1 OIL FILLER NECK AND CAP
2 ACCESSORY OIL DRAIN CONNECTION PLUG
3 STARTER POWER CABLE TERMINALS
4 MAGNETO SWITCH WIRE TERMINAL (SPECIAL)
5 UPPER HYDRAULIC PUMP MOUNT PAD (IRON)
6 PROPELLER GOVERNOR DRIVE COVER
7 ELECTRIC TACHOMETER GENERATOR
8 LOWER HYDRAULIC PUMP DRIVE COVER
9 EXHAUST FLANGE STUDS
10 ACCESSORY OIL DRAIN CONNECTION PLUG
11 1, 3, 5 SIDE REAR ENGINE MOUNT
12 OIL OUTLET TEMPERATURE CONNECTION PLUG
13 OIL PRESSURE RELIEF VALVE CAP
14 OIL PUMP DISCHARGE HOSE
15 OIL SUMP DRAIN PLUG
16 FUEL PUMP DISCHARGE PORT
17 FUEL PUMP INLET PORT
18 2, 4, 6 SIDE REAR ENGINE MOUNT
19 OIL DILUTION CONNECTION PLUG

Figure 8–2. Rear View of Engine



1 GENERATOR WIRE TERMINALS
2 ENGINE LIFTING EYE
3 PRIMING DISTRIBUTOR FUEL INLET
4 CRANKCASE BREATHER ELBOW
5 CRANKCASE OIL OUTLET HOSE ADAPTER
6 THROTTLE LEVER (LEFT SIDE)
7 MIXTURE CONTROL AND IDLE CUT-OFF LEVER
8 FUEL PRESSURE GAGE CONNECTION PLUG
9 CARBURETOR FUEL INLET CONNECTION
10 FUEL VAPOR RETURN LINE CONNECTION
11 CARBURETOR REGULATOR VENT PLUG
12 CARBURETOR REGULATOR CHAMBER DRAIN PLUG

Figure 8–3. Right Side View of Engine

Note

Care must be exercised to insure that the threaded area of all connecting fittings to the carburetor are free from nicks, burrs or other thread damage which might cut or shave off aluminum cuttings from the regulator cover and force them into the unprotected cavity around the poppet valve. Extreme care should also be exercised when applying Seal Lube or other thread compounds to the above connections. Use sparingly. A large number of carburetor difficulties have been traced to the presence of thread compound and thread shavings in the metered fuel channels and poppet valve cavity of the carburetor causing erratic engine operation or complete engine stoppage.

8–14. TEST PROCEDURES AND LIMITS.

8–15. ENGINE RUN IN SCHEDULES. Engine test will be accomplished according to the schedules and limits set forth in figures 8–4 and 8–5.

8–16. Test limits as specified in figures 8–4 and 8–5 supersede those listed elsewhere.

8–17. MAXIMUM ALLOWABLE CYLINDER TEMPERATURES. Refer to Table XI for maximum allowable cylinder temperatures.

TABLE XI. MAXIMUM ALLOWABLE CYLINDER TEMPERATURES

INDICATION	WHERE MEASURED	MAXIMUM ALLOWABLE
Cylinder Head Temp.	Down-stream spark plug gasket	274°C (525°F)
Cylinder Base Temp.	Cylinder Barrel Fillet	157°C (315°F)

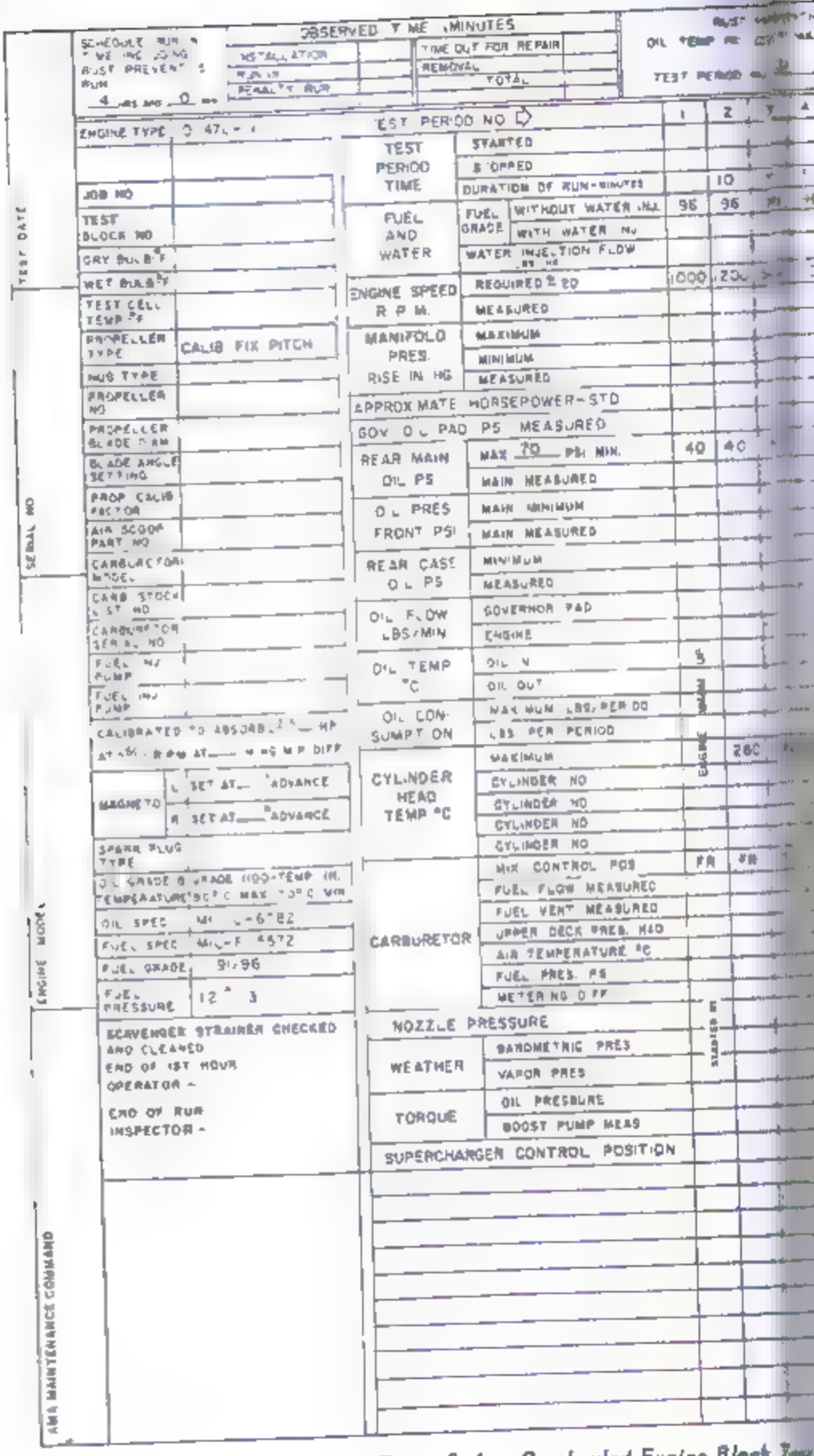


Figure 8—4. Overhauled Engine Block Test

RUST PREVENTIVE RUN
OIL TEMP IN: [illegible]°C MAX 105°C MIN.
TEST PERIOD NO. 2

OVERHAULED ENGINE BLOCK TEST

RECORD READINGS AT EACH TEST PERIOD-REFER TO TM-1-2R

		2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
RUN MINUTES		0	5	5	5	5	5	15	15	15	5	15	15	15	5	15	3	2			15								
WATER IN	96	96	96	96	96	96	96	96	96	96	96	96	96	96	96	96	96	96	96	96	96								
WATER INJ.																													
FLOW																													
	1000	1200	1500	700	800	800	900	900	2150	2250	2150	2250	2300	2300	2300	2300	2600	2050	600		500								
									89	89	89	89	-54	-54	-54	-54													
									-109	-109	-109	-109	-74	-74	-74	-74													
STD										104	104	104	148	148	148	148	213												
MEASURED																													
PS MIN.	40	40	50	50	55	55	60	60	60	50	60	60	60	60	60	60	60	60											
PERIOD														66	66	66													
PERIOD																													
		240	260	260	260	260	274	274	274	276	276	274	274	274	274	274	274	274											
POS	FR	FR	FR	FR	FR	FR	FR	FR	FR	FR	FR	FR	FR	FR	FR	FR	FR	FR	FR	FR	FR								
MEASURED																													
MEASURED																													
PRES HIO																													
RE °C																													
PS																													
PRES																													
PRES																													
RESSURE																													
MEAS																													
POSITION																													

Overhauled Engine Block Test

LED ENGINE BLOCK TEST

AT EACH TEST PERIOD-REFER TO TM-1-2R-1-12

19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
		15														
96	96	96														
00		1500														
R	FR	FR														

OIL READINGS	
TEST PERIOD NO	16
MAXIMUM LIMIT	45
[illegible] LIMIT	
MEASURED	

SUPERCHARGER CLUTCH TEST

	PERIOD NO	RPM	PRESSURE MANIFOLD	PRESSURE CLUTCH OIL	PRESSURE ENGINE OIL
LOW			IN. HG.	PSI	PSI
HIGH			IN. HG	PSI	PSI

CHECK LIST	S	US
[illegible]		
[illegible]		
MAGNETO BREAKER COMPARTMENT		
OPERATION OF IDLE CUT-OFF		

MAGNETO CHECK

75 MAX. RPM DROP PERIODS 9 & 6

TEST PERIOD NO	LEFT	RIGHT
NO. 2		
NO 5		
NO 9		
NO. 16		

MAGNETO TYPE	MAGNETO SERIAL NO.	
ENGINE TESTED BY	OPERATOR'S SIGNATURE	
LOG SHEET COMPLETE	INSPECTOR'S SIGNATURE	
ENGINE ACCEPTED	DATE	INSPECTOR'S SIGNATURE
ENGINE REJECTED	DATE	INSPECTOR'S SIGNATURE

NOTES:

1. Log all unscheduled runs including warm-ups in blank test periods
2. Desired oil pressure 65 psi

REMARKS: At no time will the engine be accelerated faster than by moderate movement of the throttle

LIMITS BY	DATE
T & O	12 MAY 1954

Figure 8–5. Overhauled Engine Block Test Clearance and Check Lists

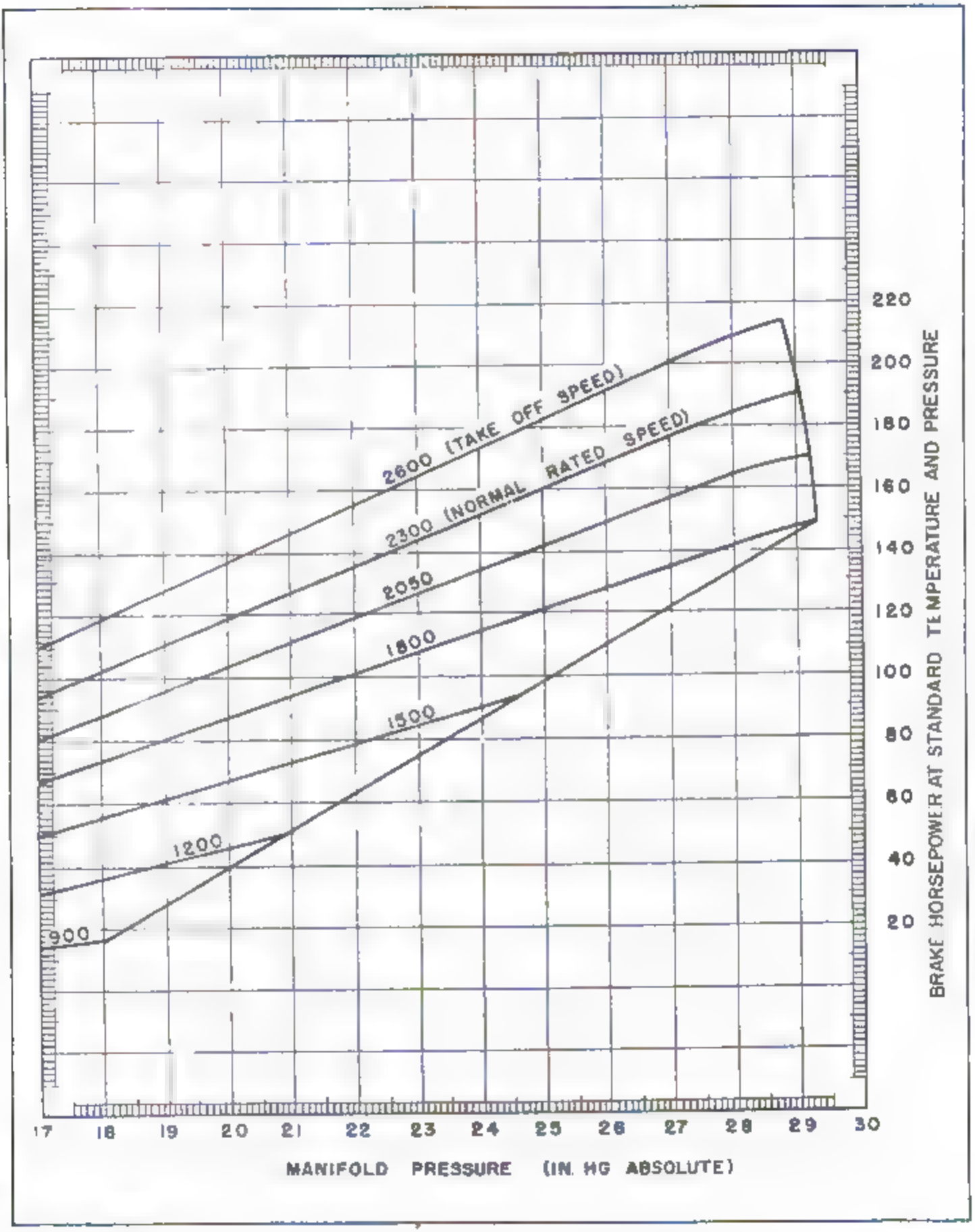


Figure 8–6. Horsepower, RPM, and Manifold Pressure at Sea Level

8–18. ENGINE PERFORMANCE CHECK. There are many variables which affect horsepower and it is not feasible for the average overhaul base to maintain the complete equipment and personnel for close horsepower measurement. When an engine has been overhauled as recommended in the proceeding sections of this technical manual it should develop essentially the same power as when new, provided the carburetor and ignition systems have also been overhauled and tested correctly. Check on manifold pressure and RPM using a calibrated test propeller in connection with the applicable curves comprised in figures 8–6 and 8–1. This should provide a sufficiently close check on horsepower output.

8–19. COMPRESSION CHECK. A cylinder compression check will be performed before the corrosion-preventive run is made, using a compression tester assembly, Type S-1, part No. 47R1192 or equivalent. To obtain consistent readings, the compression test must be performed immediately after the engine has been shut down. The minimum allowable compression for the Type S-1 tester is 60 psi. The applicable section of TM 1-2R-1-12 should be consulted for detailed instructions and corrective action for cylinders that do not meet this minimum.

8–20. CORROSION PREVENTIVE RUN. In the final period of the run schedule, the engine will be operated at 1500 rpm for 15 minutes on corrosion preventive mixture. See TM 1-2R-1-12 for specific mixture. Oil that was used during test will drain from the engine and corrosion preventive mixture that has been heated to a temperature of 105°C to 122°C (221°F to 250°F) will be added in quantities as specified in paragraph 8–4.

8–21. ASPIRATION. At the conclusion of the corrosion preventive period, the engine induction passages and combustion chamber will be treated with corrosion preventive mixture. This will be accomplished by aspiration in the following manner. Install discharge nozzle into the induction system. Temperature of the mixture will not be lower than 105°C (221°F). With engine operating at 1500 RPM, turn mixture into induction system. As soon as white smoke appears at the stacks, move mixture control to idle cut-off. Aspiration should continue until engine speed drops to 100 RPM.

SECTION IX

ACCESSORIES

9–1. CARBURETOR.

9–2. Complete information for rebuilding and testing Stromberg model PS-5C carburetors will be found in TM 1-6R1-3-5-3.

9–3. MAGNETOS.

9–4. Instructions for rebuilding and testing Scintilla model S6LN-21 magnetos will be found in TM 1-8E2-5-3-13.

9–5. STARTER AND GENERATOR.

9–6. For overhaul and testing instructions relative to the direct cranking electric starter, Bendix-Utica part number 756-10-C, refer to TM 1-8D12-3-8-23.

9–7. For overhaul and testing instructions relative to the Eclipse 24 volt generator, part number 1345-3-A, refer to TM 1-8D3-6-1-31.

9–8. TACHOMETER GENERATOR.

9–9. The AN5547-2 tachometer generator may be a unit manufactured by either Jack & Heintz or General Electric. Overhaul instructions for the General Electric unit are contained in TM 1-5E5-3-1-33, while overhaul instructions for the Jack & Heintz unit are contained in TM 1-5E5-3-3-23.

9–10. FUEL PUMP.

9–11. For overhaul instructions relative to Romec fuel pump, part number RG-9080 (Type G-18), see TM 1-6R5-3-8-3. Overhaul instructions for the Romec fuel pump, part number RD7790-N, will be found in TM 1-6R5-3-7-3.

SECTION X

TABLES OF LIMITS WITH LIMITS AND LUBRICATION CHARTS

10–1. INTRODUCTION

10–2. The tables of dimensional limits and tightening torques contained in this section and Charts 1, 2, 3, 4, and 5 shall be used in connection with inspection, repair, and assembly operations described in preceding sections of this publication

10–3. In the following table, dimensional limits are placed in three columns. Values in the two columns under the heading, "New Parts," apply when both mating parts concerned in a specification of fit are new parts, drawn from stock for replacement purposes, or when the dimension applies to a single part of the same status. Dimensions placed in the "Replace. Maximum" column represent the greatest departure from desired fits, sizes, and strength permissible in rebuilt engines and apply to used parts. It will be observed that "Replace. Maximum" dimensions are not always larger in numerical value than corresponding dimensions of new parts

10–4. Minimum and maximum values of dimensions applicable to new parts are set up as ideal limits. Measurements which indicate no greater departure from ideal sizes and clearances and strength than the replacement maximums permit the parts concerned to be continued in service. When no figure appears in the "Replace. Maximum" column, the fit must be within limits stated in the "New Parts" columns Use oversize replacements where necessary to maintain such fits

10–5. Parts worn to the extent that their fits with serviceable mating parts are beyond replacement maximum dimensions shall be discarded only when no applicable repair process is described in Section V. Use dimensional information to determine wear of individual parts not covered by special gages

10–6. In the following tables, loose fits – such as diametrical clearances, side clearances, and end plays – are denoted by the letter "L" following the numerical value. Interferences (tight fits), in which the female part is smaller than the male part – when measured at room temperature – are denoted by the letter "T". The abbreviation "Replace. Maximum" indicates the term "Replacement Maximum," defined in paragraphs 10–3 and 10–4. All dimensions are stated in inches

TABLE OF LIMITS

REF NO.	CHART NO.	DESCRIPTION	NEW PARTS MINIMUM	NEW PARTS MAXIMUM	REPLACE MAXIMUM
		CYLINDER AND HEAD ASSEMBLY			
1	1	Cylinder bore (lower 3–3/8 inch of barrel) ... diameter	5.001	5.003	5.006
2	1	Cylinder bore (at top of barrel) ... diameter	4.991	4.995	5.000
3	1	Cylinder bore choke (from 2-3/8 inches above flange to top)	0.008	0.010	
	1	Cylinder bore choke (from 3-1/4 inches above flange to top)	0.010	0.012	
4	1	Cylinder bore ... out of round:			0.002
5	1	Cylinder bore ... allowable oversize			0.015
6	1	Intake valve seat insert in cylinder head ... diameter:	0.009T	0.012T	
7	1	Exhaust valve seat insert in cylinder head ... diameter:	0.007T	0.010T	
8	1	Intake valve guide in cylinder head ... diameter:	0.001T	0.0025T	
9	1	Exhaust valve guide in cylinder head ... diameter:	0.001T	0.0025T	
10	1	Intake valve seat ... width:	0.107	0.156	
11	1	Exhaust valve seat ... width:	0.120	0.171	
12	1	Valve seat to guide axis ... angle:	44° 30′	45°	
		ROCKER ARMS AND SHAFT			
13	1	Rocker shaft in cylinder head bosses ... diameter:	0.000	0.0015L	0.003L
14	1	Rocker shaft in rocker arm bearing ... diameter:	0.001L	0.0025L	0.004L
15	1	Rocker arm bearing in rocker ... diameter:	0.0005T	0.0025T	
16	1	Rocker arm assembly ... side clear:	0.004L	0.011L	0.015L

TABLE OF LIMITS (CONT)

REF. NO	CHART NO	DESCRIPTION		NEW PARTS MINIMUM	NEW PARTS MAXIMUM	REPLACE. MAXIMUM
		VALVES				
17	1	Intake valve in guide	diameter:	0.0012L	0.0032L	0.005L
18	1	Exhaust valve in guide	diameter:	0.003L	0.005L	0.008L
19	1	Intake valve face (to axis)	angle:	45°	45° 30'	
20	1	Exhaust valve face (to axis)	angle:	45°	45° 30'	
21	1	Intake valve	length:	4.804	4.824	4.789
22	1	Intake valve maximum tip regrind				0.015
23	1	Exhaust valve	length:	4.806	4.826	4.791
24	1	Exhaust valve maximum tip regrind				0.015
		PISTONS, RINGS AND PINS				
25	1	Piston bottom skirt in cylinder	diameter:	0.008L	0.011L	0.016L
26	1	Piston below third groove in cylinder	diameter	0.015L	0.021L	0.024L
27	1	Top piston ring in groove	side clear:	0.007L	0.0085L	0.013L
28	1	Second piston ring in groove	side clear	0.0055L	0.007L	0.012L
29	1	Third piston ring in groove	side clear:	0.003L	0.0045L	0.007L
30	1	Compression rings (in cylinder barrel)	gap	0.028	0.044	0.055
31	1	Compression rings (in cylinder barrel)	gap	0.028	0.044	0.055
32	1	Oil control ring (in cylinder barrel)	gap	0.028	0.044	0.055
33	1	Plug in piston pin (P/N 352034 to P/N 35977)	diameter	0.000	0.002	0.003T
34	1	Plug in piston pin (P/N 530843 to P/N 530844)	diameter:	0.0005T	0.0025T	
35	1	Piston pin in piston	diameter	0.0005L	0.0012L	0.002L
36	1	Piston pin and plugs in cylinder	end clear	0.036L	0.048L	0.060L
37	1	Piston pin in connecting rod bushing	diameter	0.0012L	0.0018L	0.003L
		CONNECTING ROD				
38	1	Piston pin bushing in connecting rod	diameter:	0.0025T	0.0050T	
39	1	Connecting rod bearing on crankpin (silver bearing)	diameter:	0.0015L	0.004L	0.006L
40	1	Connecting rod bearing on crankpin (tri-metal bearing)	diameter:	0.0009L	0.0034L	0.006L
41	1	Connecting rod on crankpin	end clear	0.006L	0.010L	0.016L
42	1	Connecting rod bearing and bushing — Twist and convergence	per inch of length:	0.000	0.0005	0.001
43	1	Bolt in connecting rod	diameter:	0.0005T	0.001L	
		CRANKSHAFT				
44	2	Crankshaft in main and thrust bearings (silver)	diameter:	0.0009L	0.0041L	0.0055L
45	2	Crankshaft in main bearings (tri-metal)	diameter:	0.0008L	0.0035L	0.0055L
46	2	Crankshaft in thrust bearing (silver)	end clear:	0.004L	0.010L	0.014L
47	2	Crankpins	out of round:	0.000	0.0005	0.0015
48	2	Main journals	out of round:	0.000	0.0005	0.0015
49	2	Main and thrust journals	diameter:	2.3734	2.375	2.372
50	2	Crankpins	diameter	2.2490	2.250	2.247
51	2	Main journals (shaft supported at thrust and rear journals) (full indicator reading)	runout:	0.000	0.015	0.015
52	2	Runout on propeller hub of flanged crankshaft (shaft supported at thrust and rear journals)	full indicator reading:	0.000	0.005	0.005
53	2	Runout on face near perimeter of flanged crankshaft propeller mount flange (shaft supported at thrust and rear journals)	full indicator reading:	0.000	0.005	0.005
54	2	Damper pin bushing in crankcheek extension	diameter	0.0015T	0.0037T	
55	2	Damper pin bushing in counterweight	diameter:	0.0015T	0.0037T	
56	2	Damper pin in bushings	diameter	0.0666L	0.0706L	0.082L
57	2	Damper pin in counterweight	end clear	0.011L	0.033L	0.050L

TABLE OF LIMITS (CONT)

REF. NO	CHART NO	DESCRIPTION		NEW PARTS MINIMUM	NEW PARTS MAXIMUM	REPLACE MAXIMUM
58	2	Crankshaft in counterweight	side clear:	0.006L	0.012L	0.020L
59	2	Crankshaft gear on crankshaft pilot	diameter:	0.000	0.002L	
		CRANKCASE				
60	2	Crankshaft oil seal in crankcase	diameter:	0.002T	0.008T	
61	2	Through bolt (10-11/16 inch long) in crankcase	diameter:	0.0005T	0.001L	
62	1	Hydraulic valve lifter in crankcase guide	diameter:	0.0005L	0.002L	0.0035L
63	4	Magneto drive gear support in crankcase	diameter:	0.0005T	0.0025T	
		CAMSHAFT				
64	2	Camshaft journals in bearings	diameter:	0.001L	0.003L	0.005L
65	2	Camshaft in crankcase	end clear:	0.005L	0.009L	0.014L
66	2	Camshaft center journals (shaft supported at front and rear journals) (full indicator reading)	runout:	0.000	0.005	0.005
67	2	Camshaft gear on flange	diameter:	0.0005T	0.0015L	
		SPRING TEST DATA				
68	1	Inner valve spring No. 35988 (compressed to 1.329 inch length)	load:	71 lb	81 lb	66 lb
69	1	Inner valve spring No. 35988 (compressed to 1.809 inch length)	load:	34 lb	38 lb	25 lb
70	1	Inner valve spring No. 520106 (compressed to 1.329 inch length)	load:	77 lb	88 lb	70 lb
71	1	Inner valve spring No. 520106 (compressed to 1.809 inch length)	load:	43 lb	49 lb	37 lb
72	1	Outer valve spring No. 35989 (compressed to 1.360 inch length)	load:	100 lb	113 lb	94 lb
73	1	Outer valve spring No. 35989 (compressed to 1.840 inch length)	load:	41 lb	47 lb	38 lb
74	1	Outer valve spring No. 520105 (compressed to 1.360 inch length)	load:	107 lb	120 lb	100 lb
75	1	Outer valve spring No. 520105 (compressed to 1.840 inch length)	load:	65 lb	71 lb	62 lb
		ACCESSORY CASE				
76	3	Magneto adapter pilot in case	diameter:	0.0005L	0.0025L	
77	3	Bushing in magneto adapter	diameter:	0.0015T	0.0035T	
78	3	Magneto cluster gear in adapter bushing	diameter:	0.0025L	0.0045L	0.006L
79	3	Sleeve in magneto cluster gear	diameter:	0.001T	0.004L	
80	3	Magneto pilot in adapter	diameter:	0.001L	0.005L	
81	3	Upper hydraulic pump drive gear in rear bushing	diameter:	0.0015L	0.0035L	0.0045L
82	3	Upper hydraulic pump drive rear bushing in case	diameter:	0.001T	0.003T	
83	3	Upper hydraulic pump drive gear	end clear:	0.010L	0.030L	0.035L
84	3	Upper hydraulic pump drive front bushing in case	diameter:	0.001T	0.003T	
85	3	Upper hydraulic pump drive gear in front bushing	diameter:	0.0015L	0.0035L	0.0045L
86	3	Upper hydraulic pump drive oil seal in case	diameter:	0.000	0.006T	
87	3	Magneto cluster gear front bushing in case	diameter:	0.001T	0.003T	
88	3	Magneto cluster gear in front bushing	diameter:	0.002L	0.004L	0.0055L
89	3	Magneto cluster gear	end clear:	0.014L	0.046L	0.051L
90	3	Fuel pump drive oil seal in case	diameter:	0.001T	0.007T	
91	3	Fuel pump drive gear in bushing	diameter:	0.0015L	0.0035L	0.005L
92	3	Fuel pump drive bushing in case	diameter:	0.001T	0.003T	
93	3	Fuel pump drive gear	end clear:	0.013L	0.033L	0.038L

TABLE OF LIMITS (CONT)

REF. NO	CHART NO.	DESCRIPTION		NEW PARTS MINIMUM	NEW PARTS MAXIMUM	REPLACE MAXIMUM
94	3	Upper tachometer drive rear bushing in case	diameter:	0.001T	0.003T	
95	3	Upper tachometer drive gear in rear bushing	diameter:	0.0015L	0.0035L	0.005L
96	3	Upper tachometer drive oil seal in case	diameter:	0.001T	0.007T	
97	3	Starter jaw oil seal in case	diameter:	0.002T	0.008T	
98	3	Starter jaw on stud	diameter:	0.010L	0.030L	
99	3	Lower tachometer drive bushing in case	diameter:	0.001T	0.003T	
100	3	Fuel pump idler gear bushing in case	diameter:	0.001T	0.003T	
101	3	Fuel pump idler gear in bushing	diameter	0.0015L	0.0035L	0.005L
102	3	Fuel pump idler gear	end clear:	0.013L	0.003L	0.038L
103	3	Propeller governor drive rear bushing in case	diameter:	0.001T	0.003T	
104	3	Propeller governor drive front bushing in case	diameter:	0.001T	0.003T	
105	3	Propeller governor drive gear in rear bushing	diameter:	0.0015L	0.0035L	0.0045L
106	3	Propeller governor drive gear	end clear:	0.010L	0.030L	0.035L
107	3	Propeller governor drive gear in front bushing	diameter:	0.0015L	0.0035L	0.0045L
108	3	Upper tachometer drive gear	end clear:	0.010L	0.030L	0.035L
109	3	Upper tachometer drive gear front bushing in case	diameter:	0.001T	0.003T	
110	3	Upper tachometer drive gear in front bushing	diameter:	0.0015L	0.0035L	0.005L
111	4	Generator drive gear in adapter bushing	diameter:	0.002L	0.004L	0.0055L
112	4	Generator drive bushing in adapter	diameter:	0.002T	0.004T	
113	4	Oil seal in generator adapter	diameter:	0.001T	0.007T	
114	4	Generator pilot in adapter	diameter:	0.003L	0.007L	
115	4	Generator drive gear	end clear:	0.003L	0.041L	
116	4	Lower hydraulic pump drive rear bushing in case	diameter:	0.001T	0.003T	
117	4	Lower hydraulic pump drive oil seal in case	diameter:	0.000	0.005T	
118	4	Lower hydraulic pump drive gear in rear bushing	diameter:	0.0015L	0.0035L	0.005L
119	4	Lower hydraulic pump drive gear	end clear:	0.010L	0.032L	0.037L
120	4	Lower hydraulic pump drive gear in front bushing	diameter:	0.0015L	0.0035L	0.0045L
121	4	Oil pump drive gear bushing in case	diameter:	0.001T	0.003T	
122	4	Oil pump drive gear in bushing	diameter:	0.0015L	0.0035L	0.005L
123	4	Oil pump drive gear	end clear:	0.013L	0.033L	0.038L
		OIL PUMP				
124	4	Oil pump driver and driven gears	end clear:	0.002L	0.005L	0.006L
125	4	Oil pump driver and driven gears in accessory case bushings	diameter:	0.0015L	0.0035L	0.0045L
126	4	Oil pump driver and driven gear teeth to pump body	diameter:	0.003L	0.005L	
127	4	Oil pump driver and driven gear shafts in pump bushings	diameter:	0.0015L	0.0035L	0.0045L
128	5	Oil screen ferrule in pump body	diameter:	0.005L	0.025L	
129	5	Oil pressure relief valve sleeve in pump body	diameter:	0.035L	0.050L	0.055L
130	5	Oil pressure relief valve sleeve in pump body	diameter:	0.002L	0.005L	0.007L
131	5	Oil pressure relief valve plunger in sleeve	diameter:	0.0025L	0.0045L	0.007L
		GEAR BACKLASHES				
132	4	Upper tachometer drive gear to optional propeller governor drive gear		0.008	0.012	0.016
133	4	Right magneto cluster gear to generator drive gear		0.008	0.012	0.016
134	4	Left magneto drive gear to optional upper hydraulic pump drive gear		0.007	0.011	0.015

TABLE OF LIMITS (CONT)

REF. NO	CHART NO	DESCRIPTION	NEW PARTS MINIMUM	NEW PARTS MAXIMUM	REPLACR. MAXIMUM
135	4	Upper tachometer drive gear to magneto cluster gears	0 008	0 012	0 016
136	4	Pinion gear to upper tachometer drive gear	0 008	0.012	0 016
137	4	Pinion gear to camshaft gear	0.008	0.012	0.016
138	4	Camshaft gear to lower hydraulic pump drive gear	0.008	0.012	0.016
139	4	Camshaft gear to oil pump drive gear	0.008	0.012	0 016
140	4	Oil pump driver gear to oil pump driven gear	0.018	0.026	0 032
141	4	Fuel pump idler to camshaft gear	0.008	0.012	0.016
142	4	Fuel pump idler to fuel pump drive gear	0.008	0.012	0.016

TABLE OF TIGHTENING TORQUES.

REF. NO.	CHART NO.	DESCRIPTION	SIZE	PER ENGINE	TORQUE (IN. LB)
		TIGHTENING TORQUES			
T1	1	Nut—Front mount bracket stud	3/8-24	8	275—325
T2	2	Nut—Crankcase through bolt	5/16-24	3	180—220
T3	2	Nut—Crankcase front through bolt	3/8-24	2	370—390
T4	2	Nut—Crankcase through bolt	7/16-20	16	400—500
T5	1	Nut—Crankcase to cylinder stud	3/8-24	36	410—430
T6	1	Nut—Connecting rod bolt (with Alcon thread lube)	3/8-24	12	340—365
T7	2	Screw—Gear to crankshaft	1/4-28	6	140—160
			5/16-24	6	240—260
T8	2	Screw—Gear to camshaft	1 4-28	4	140—160
			5/16-24	4	240—260
T9	1	Spark plug (with mica thread lube)	18mm.	12	320—380
T10	1	Other nuts and cap screws	1/4-28		90—110
T11	1	Other nuts and cap screws	5/16-24		180—220
		Generator drive retaining nut	5/16-24	4	175—200
		Nut—Magneto gear support	5/16-24	4	180—220

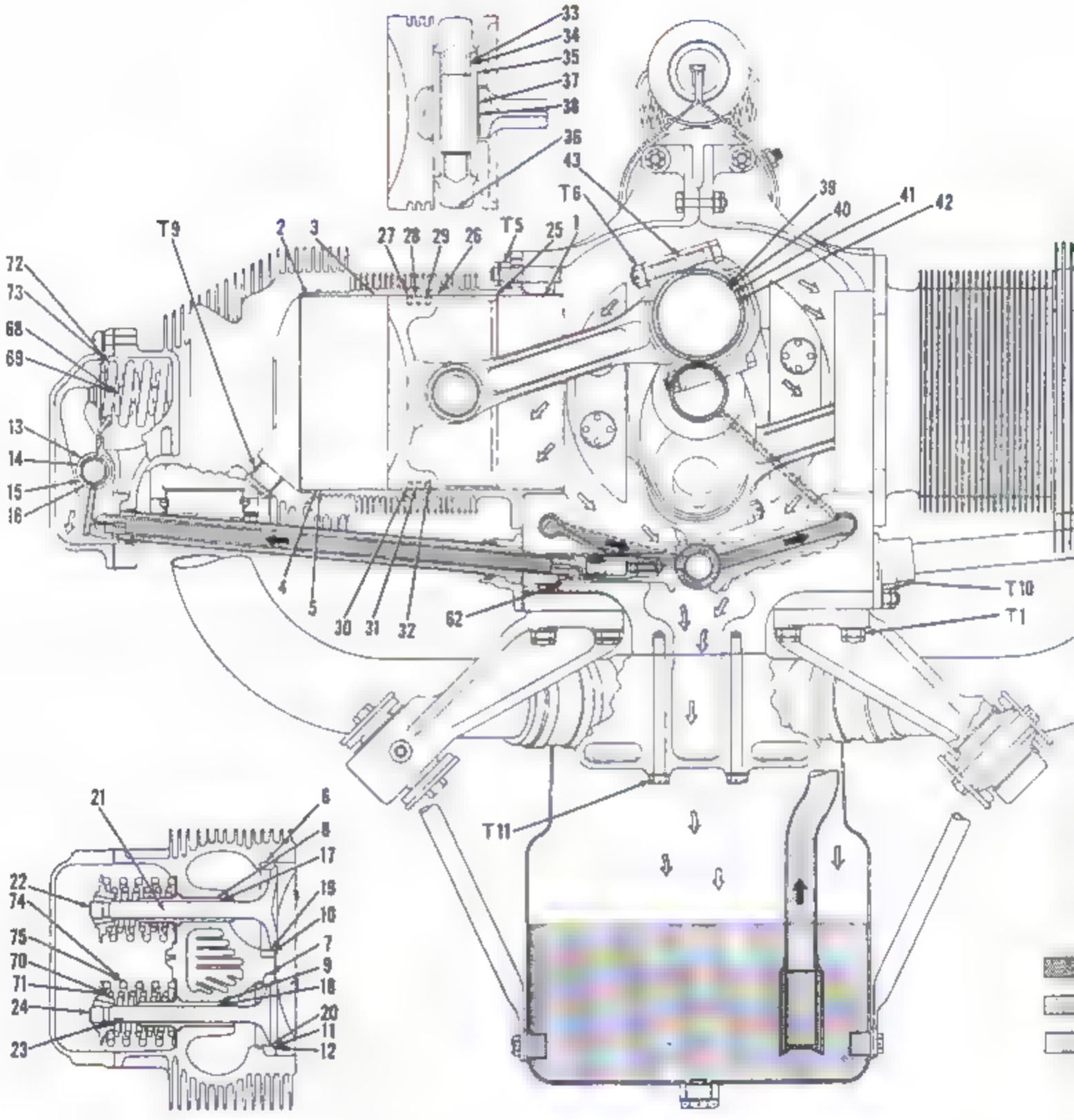
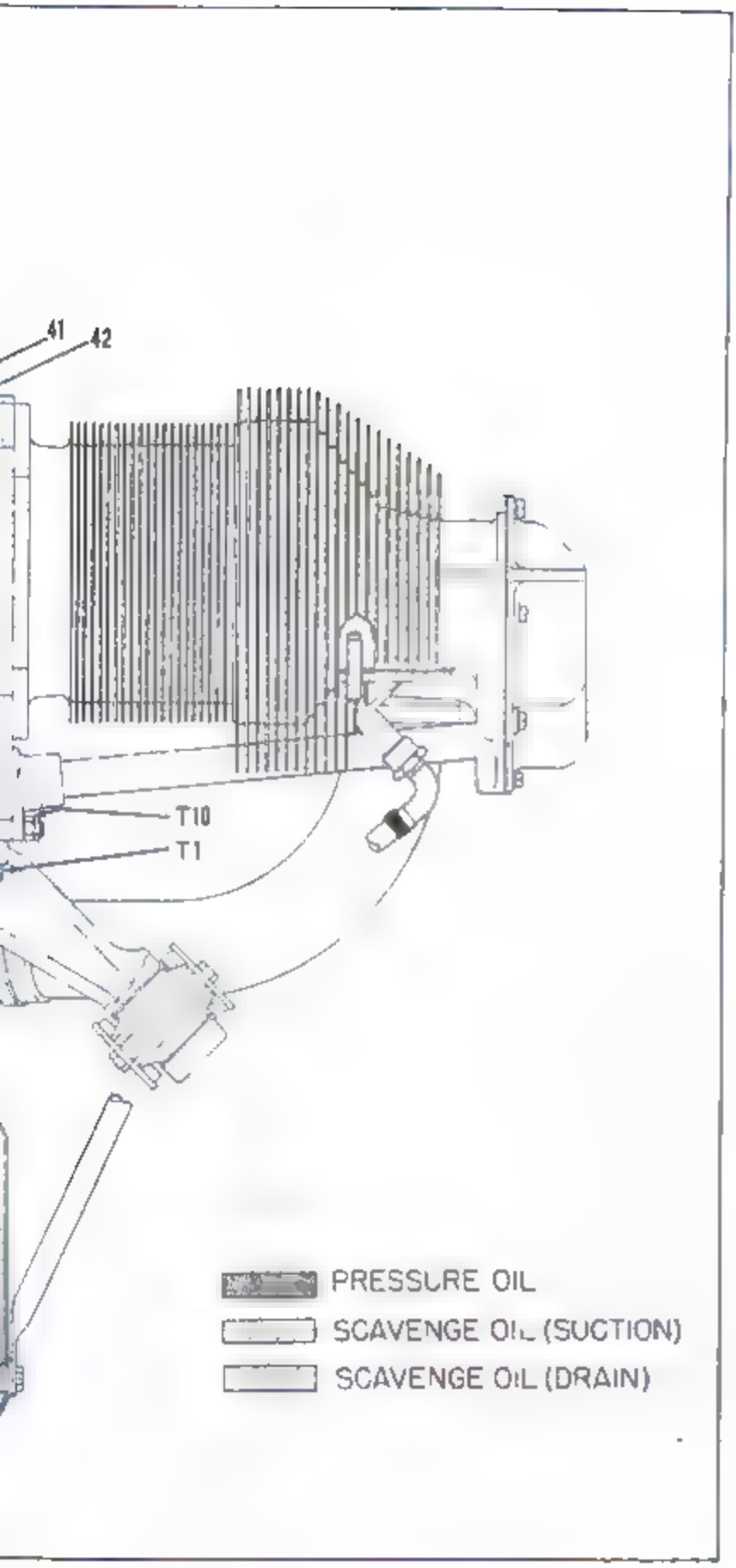


Chart 1. Limits and Lubricat


41
42
T10
T1
PRESSURE OIL
SCAVENGE OIL (SUCTION)
SCAVENGE OIL (DRAIN)

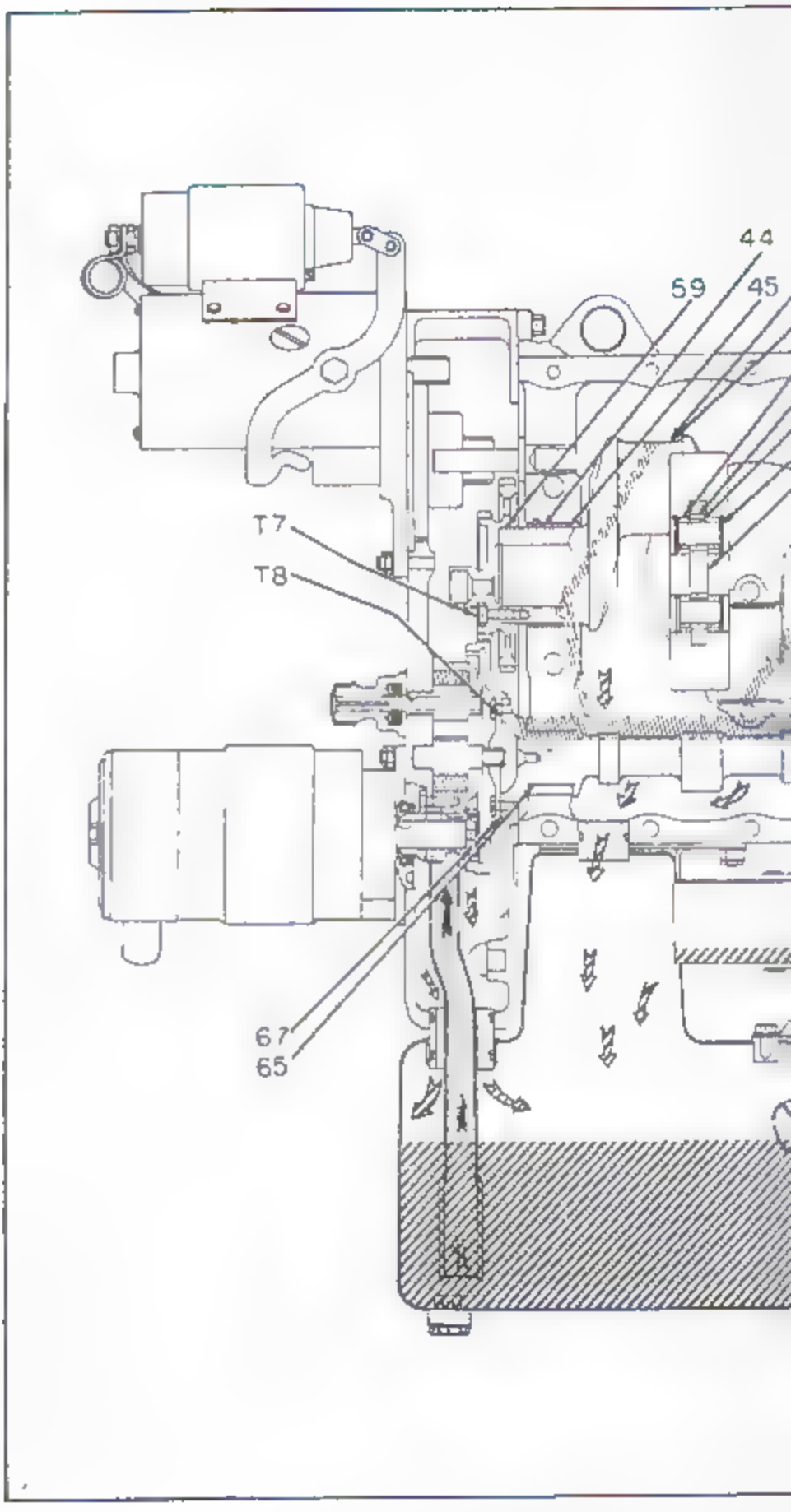
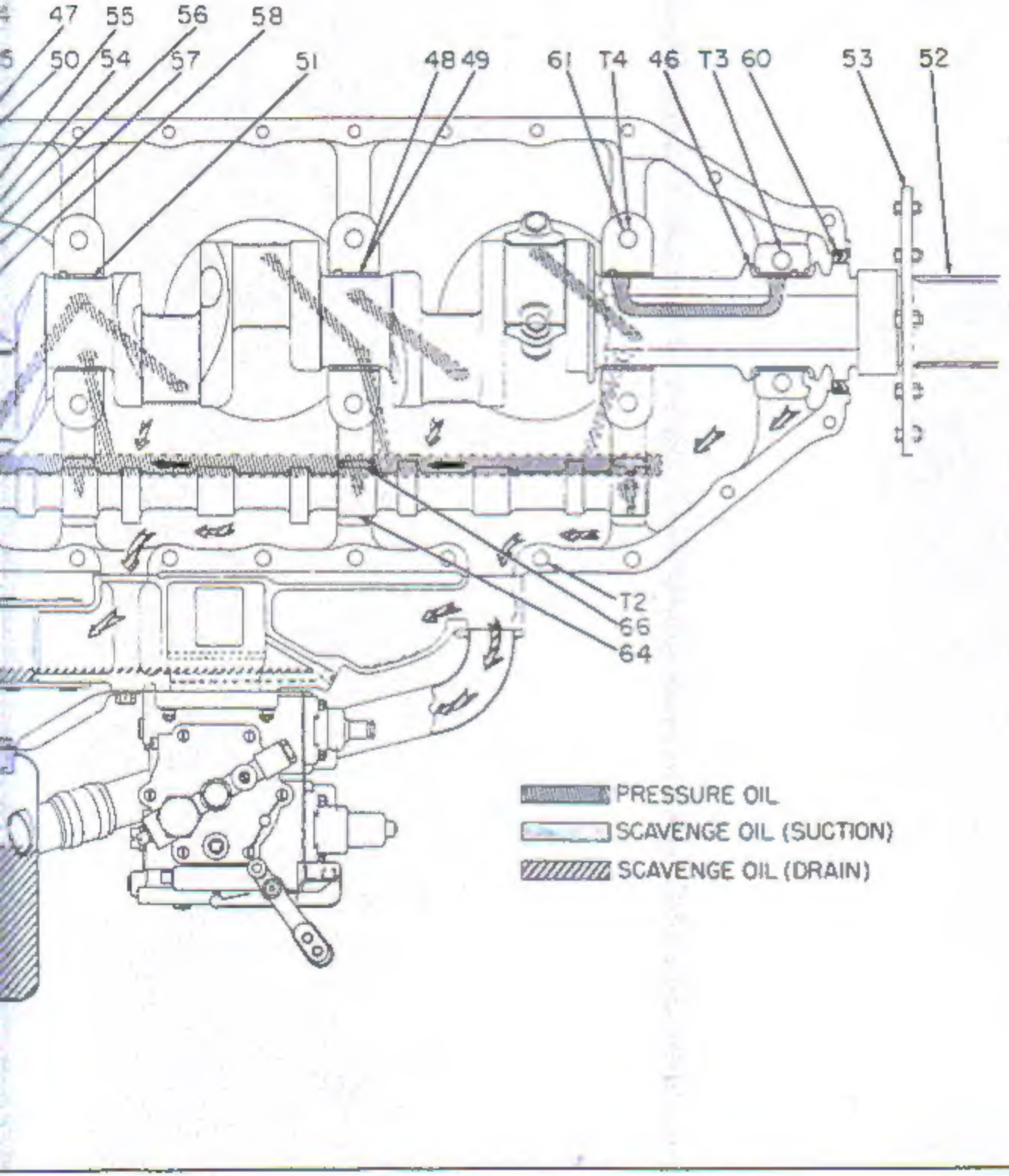


Chart 2. Limits and Lubrication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T4
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T3
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T2
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PRESSURE OIL
SCAVENGE OIL (SUCTION)
SCAVENGE OIL (DRAIN)

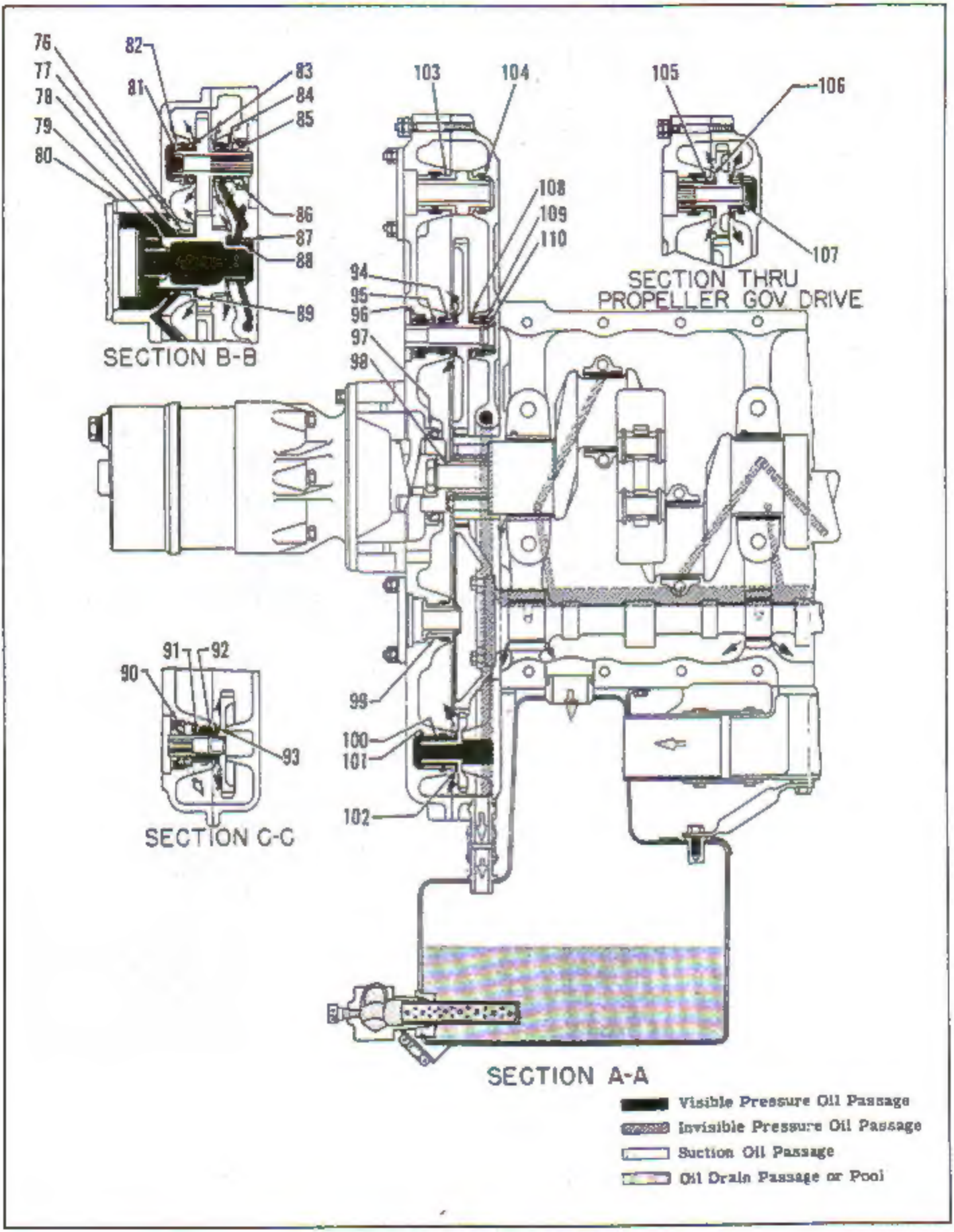


Chart 3. Limits and Lubrication

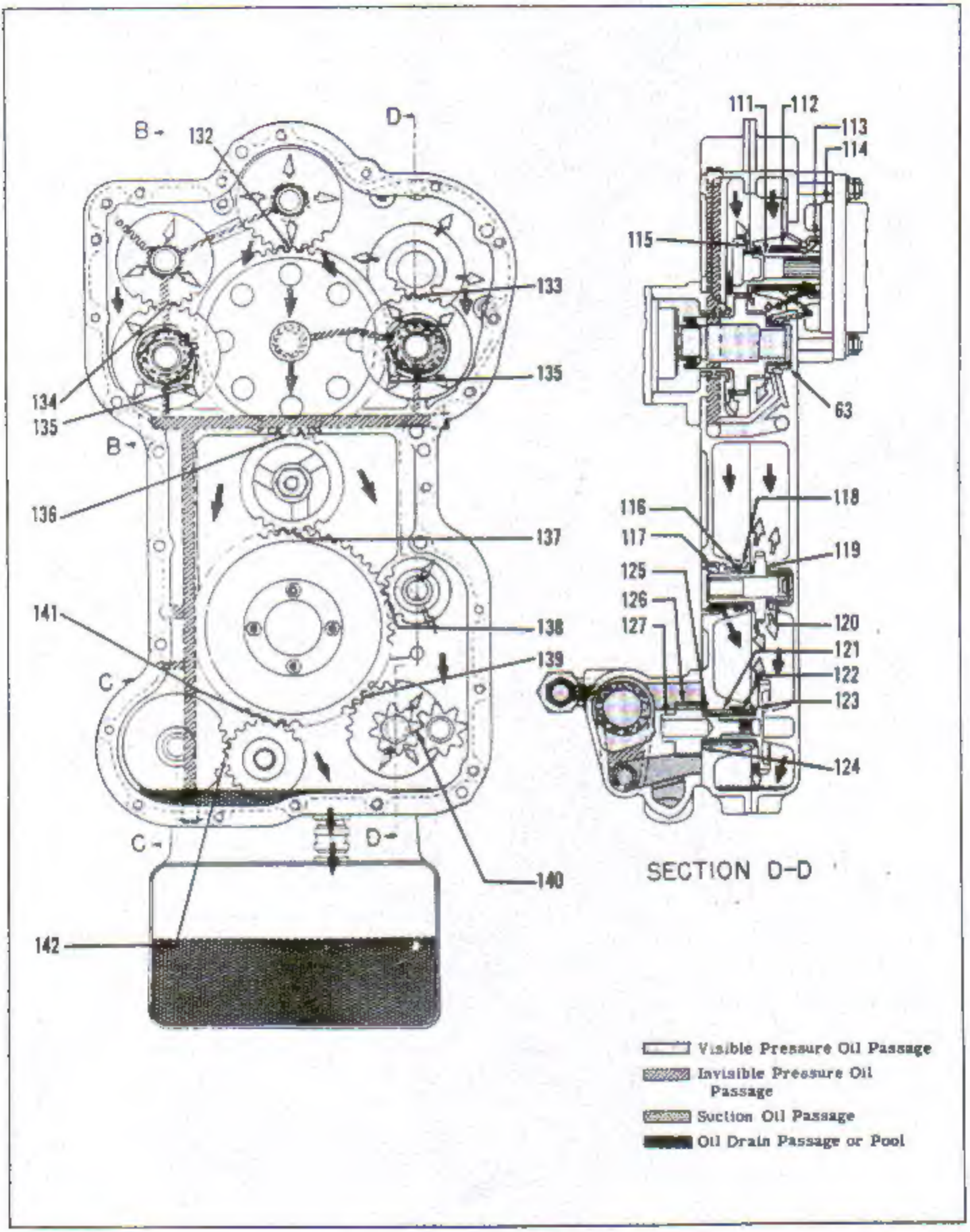
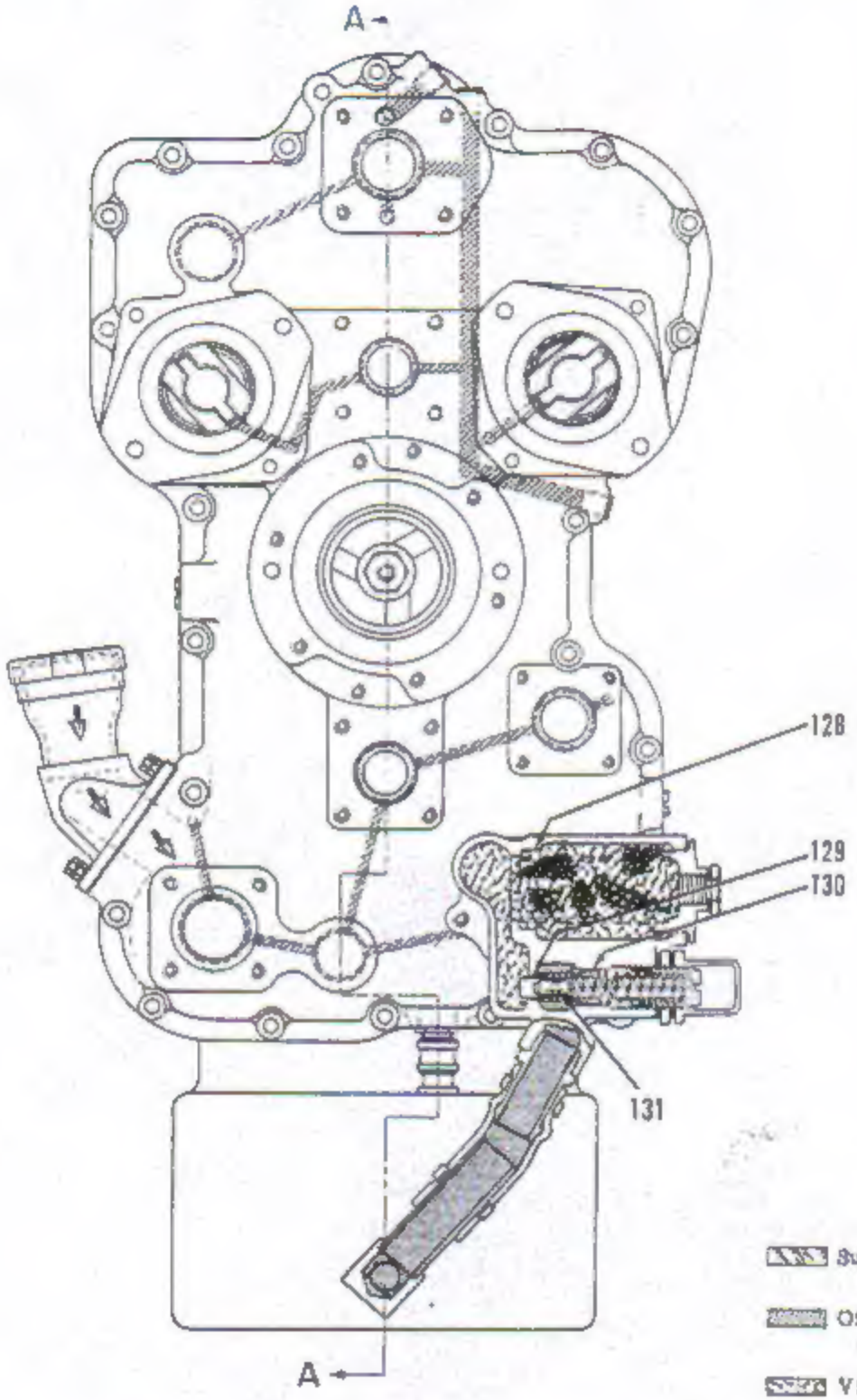


Chart 4. Limits and Lubrication



REAR VIEW OF ACCESSORY CASE AND SECTION THRU OIL PUMP

Chart 5. Limits and Lubrication

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